GENERAL FISHERIES COMMISSION
FOR THE MEDITERRANEAN

COMMISSION GÉNÉRALE DES PÊCHES
POUR LA MÉDITERRANÉE

GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN
SCIENTIFIC ADVISORY COMMITTEE (SAC)
Sub-Committee on Stock Assessment (SCSA)
REPORT OF THE WORKING GROUP ON STOCK ASSESSMENT OF SMALL PELAGIC SPECIES Split, Croatia, 05-09 November 2012

INTRODUCTION

1. The meeting of the SCSA Working Group on Small Pelagic species (WG) was held in Split, Croatia, from 05 to 09 November 2012 at the conference room of the Best Western Art Hotel in Split. It was attended by 19 participants from GFCM Member Countries, FAO Regional Projects as well as representatives of the GFCM Secretariat (see list of participants in Appendix B).

2. Ms. Pilar Hernandez and Mr. Miguel Bernal, GFCM Secretariat, welcomed the participants and thanked them for attending this meeting, as well as the Croatian Authorities for their kindness in hosting and arranging the meeting.

3. Ms. Piera Carpi, Italian scientist working at the Istituto di Scienze del Mare in Ancona (Italy) was proposed as Moderator. The terms of reference of the meeting are presented in Appendix C.

4. Ms. Polona Pengal was appointed as reporter.

5. The agenda was introduced by Miguel Bernal and adopted by the WG with some changes, i.e. the inclusion of a discussion on reference points for small pelagic stocks and a presentation from Algeria and Black Sea (Appendix A).

6. All the stock assessment forms presented and prepared during the WG are attached as appendices and are available at the GFCM web site.

PROGRESS ON LAST YEAR RECOMMENDATIONS

7. The GFCM Secretariat summarized 2010 and 2011 recommendations on research from the previous meeting and recall participants to provide inputs and insights on the progress done if any and on their opinion on either adopting and go forward with them or change the approach according to suitability of methods and means. The topics addressed were:
   - Understanding stock identity and migrations
   - Biological sampling
   - Reference points
   - Surveys
   - Assessment methods
   - Presentation of the new stock assessment forms prepared for this year

   The participants raised the need to review the format of the stock assessment forms, in particular the last section on advices. There was a general agreement about the new format of the SAFs, but several members raised the necessity to review the tables for the stock status, which can be misleading and ambiguous. The agenda was adapted to dedicate some slots to discuss about the matter.

   The need for more area-based studies on growth parameters and age/length keys and the convenience of sharing them throughout different areas was presented again during this year discussion.

   The issue about the definition of reference points for the Mediterranean pelagic stocks was also raised and it was decide to dedicate a part of the meeting to the discussion. The validity of reference fishing mortality rates as a threshold (such as the Patterson's threshold for the exploitation rate, which have been mainly used by the small pelagic WG in the Mediterranean) is highly dependent on life history characteristics, particularly on the degree of density dependence in the stock-recruitment relationship. The proposal of defining biomass reference points was raised and the methodology to estimate those was discussed during the meeting.

JUSTIFICATION OF THIS YEAR PROCEDURES

8. Based on the approach suggested by the Scientific Advisory Committee (SAC), the group discussed a common guideline to provide a coherent advice across the different stocks evaluated. The following issues were discussed and agreed by the group:

   - The group endorsed separating the assessment of stock status in three questions: status of the biomass, fishing mortality level and trends in biomass and recruitment.

   - The precautionary fishing mortality reference point based on Patterson's criterion (F/Z = 0.4) was the main one used up to now by some of the stocks evaluated. In addition to this, this year the group made the effort to define some biomass reference points (namely B_{lim} and B_{pa}) based on the evaluation of the assessed time series (see below).

   - B_{lim} was defined as the lowest value in the more recent time series (i.e. the recent period on which estimates – e.g. estimates of catches or direct estimates – are considered more reliable than in the rest of the time series). Whenever a longer time series was available, the consistency of this minimum value with the lowest of the entire series was evaluated. B_{pa} was established as 40% higher than B_{lim}, as a common rule for all stocks for which B_{lim} is proposed this year. Conceptually, B_{lim} is a limit biomass below which recruitment may be impaired and/or the capacity of the stock to regenerate is uncertain. B_{pa} is a precautionary reference point that, taken into consideration uncertainties in estimators, ensures with a high probability (usually around 95%) that the "true" biomass of the stock is not below B_{lim}. B_{pa} is therefore the biomass below which actions should be taken to move the stock biomass to a safe situation. The WG will further investigate (e.g. by simulation) if the general relationship between B_{lim} and B_{pa} adopted this year is appropriate or else if specific rules should be taken for each stock based on the confidence limits/variance of the stock assessment (see also the *General Discussion* section).

9. For those stocks for which reference points are not available, and following the precautionary approach which requires to provide advice with the available data, the group continued with the approach proposed last year, i.e. :

   a. When long time series of estimates were available, the status of the biomass and the evaluation of current fishing mortality levels were done in relation to the abundance and fishing mortality levels observed in the time series. Main criteria to assess the status of both stock and fishing mortality using the time series were i) the stability of stock biomass levels, ii) signals of changes in growth and/or age/length composition, iii) signals of recruitment impairment and iv) on changes in fishing mortality levels.
   b. When analyzing time series of stock status, the group adopted a Regime-Specific Harvest Rate (RSHR - Polovina, 2005; King et al., 2010) conceptual approach; it was recognized that small pelagic fish may show medium term fluctuations in productivity, due to environmental control. Therefore, the possibility for each stock to have different equilibrium biomass levels (and therefore surplus biomass and Maximum SustainableYield) at different ecosystem status was adopted. In case various productivity phases are identified, stability as defined in a) above was evaluated in relation to each phase.
   c. When no extra information was available to evaluate the productivity of the stock in each of the potential high or low abundance phases, the stability of stock characteristics in the time series was used as a guideline.
   d. When no long time series of estimates or reference points were available, harvest rates (proportion of catches to biomass) and comparison with biomass levels of other stocks of the same species across the Mediterranean, as well as rough estimates of stock unit were used to provide a rough evaluation of stock status.

10. The group proposes new tables to summarise the status of the stock to be incorporated in the new Stock Assessment forms. These tables are presented in Annex D and allow to incorporate some assessment of the trends observed in biomass and recruitment. Small pelagic fish show large fluctuations in the recruitment, which can determine the success of the next year cohort or the depletion of the following year stock. Those high fluctuations are driven by several complex factors, such as environmental variables, and cannot, in general be predicted. Signals such as the amplitude of recruitment and biomass fluctuations, as well as the potential trends and/or existence of cycles and their frequency are therefore important to provide advice on the state of the stock.

11. The working group agreed on adding figures on biomass/spawning stock biomass, recruitment and F in the advice section.

12. The group also proposes that environmental variables deemed important for stock dynamics should be incorporated in the Stock Assessment form, in order to be able to support potential future implementation of environmental variables into stock assessment models.

OVERVIEW OF ASSESSMENTS PERFORMED AND STOCK STATUS

13. A total of 12 stocks or stock units analyses have been presented to this year WG, from which a total of 10 stocks are formally assessed (a stock status is provided; see Table below). For three of the 10 stocks formally assessed (sardine in GSAs 01 and 03, sardine in GSA04 and horse mackerel in GSA29) the assessment is considered preliminary, while the rest of the stock assessments are considered validated by the group. All assessment had been done before the meeting although some extra analysis in some of the stocks was carried out during the meeting.

14. In terms of GSA areas, 8 GSA areas were covered, from which 8 areas are formally assessed (some of those have only a preliminary assessment).

15. Sardine and anchovy are the two species analysed in most of the areas, while the Black Sea presented sprat and horse mackerel.

16. Fishery independent methods are used in 7 of the formally assessed stocks, either as a tuning index for analytical assessment or else as the only biomass estimator. Acoustics is the most used method (7 out of 7 of these assessments); Daily Egg Production Method SSB estimator is used for a preliminary estimation of the SSB only for 1 stock (anchovy in GSA 18).

17. The countries on the Alboran Sea (namely Spain, Morocco and Algeria) are working towards the achievement of a common scientific survey to fully cover the sardine stock.

18. In relation to the assessment model, most stocks with analytical assessment were analysed using either length or (most commonly) age based cohort analysis. Two stocks (sardine and anchovy in GSA 16) were analysed using a biomass (Surplus) model, allowing for an external index of ecosystem productivity. One stock (sardine in GSA 04) used a Schaefer model for a preliminary assessment.

19. Four of the formally assessed stocks were classified as fully exploited and two of them as overexploited. Sardine stock off the southern Sicilian cost (GSA 16) was considered sustainably exploited, even though the estimated biomass is low. The status of the anchovy stock in the northern Adriatic Sea (GSA17) and of sprat in the Black Sea (GSA 29) was considered sustainably exploited with intermediate abundance. The status of horse mackerel in the Black Sea is uncertain due to poor information on the fishery and the lack of a joint survey.

20. In accordance to the previous results, the recommendation in the different stocks is either to reduce or maintain current fishing effort.

21. This year, neither stocks assessment nor data of any kind has been presented regarding small pelagic stocks in Spanish waters, apart from the combined exercise in GSAs 1 and 3. Also, no Spanish scientist attended the WG. The Group hopes this situation to be solved in the near future in order to continue the previous attendance and participation of Spanish experts in the assessment of small pelagic fish in the GFCM area of competence.

GSA	Species	Assessed by	Exploitation rate	Biomass level	Status	Recommendation
01-03[1]	Sardine	VIT	High	Intermediate	Under overexploitation	Reduce the level of fishing mortality by 30%.
04[1]	Sardine	Shaefer model/VIT	-	-	Fully exploited	Preliminary assessment: no advices can be provided.
07	Sardine	Acoustic and CPUE	Very Low	Very low, but positive signs in the last year	Fully exploited with no room for further expansion	Fishing effort is already low and shouldn't increase until the stock recovers
16	Sardine	Harvest Rate and Surplus production model (BioDyn)	Between low and moderate (harvest rate = 11.9%)	Lower than B_{MSY}	Sustainable exploited with a low abundance, slightly increasing in the last years	Fishing effort should not be allowed to increase
17	Sardine	VPA, ICA and acoustic survey	Higher than the Patterson's reference point (E=0.52)	Intermediate, steep increase in the last years	Fully exploited with no room for further expansion	Fishing effort should not be allowed to increase
07	Anchovy	Acoustic and CPUE	Low	Low, stable in the last 10 years	Fully exploited, low commercial-sized anchovy abundance	Fishing effort should not be allowed to increase
16	Anchovy	Harvest Rate and Surplus production model (BioDyn)	High	Low, slightly above B_{pa}	Overexploited	Fishing effort should be reduced by means of a multi-annual management plan until there is evidence for stock recovery
17	Anchovy	VPA, ICA and acoustic survey	Moderate (E = 0.4)	Intermediate	Sustainable exploited	Fishing effort should not be allowed to increase
29[1]	Horse Mackerel	Separable VPA	Uncertain	Low	High fishing mortality, but exploitation rate is uncertain	Joint surveys, regional coordination in the sampling process and development of a fishery information system
29	Sprat	ICA	Moderate	Medium to high levels	Sustainable exploited	Status quo exploitation for 2012 which implies catches of 100000 tons not to be exceeded

[1] Assessments of sardine in GSA 01-03, sardine in GSA04 and horse mackerel in GSA 29 are considered preliminary (see their respective sections for reasons).

STOCK ASSESSMENTS BY AREA AND SPECIES

22. This year, some preliminary combined assessments on neighbourhood areas were presented. In order to accommodate this, and taking into account that in the future other areas that share stocks may be assessed in common, the individual stock assessments were first organized by areas and then by species. Whenever a combined area exercise and/or assessment was carried out, the results of the combined exercise are presented first, and then the individual assessment of each subarea is included. This year the stock assessment forms for each stock will also be included in the report as annexes.

23. The WG congratulated the AdriaMed team and the involved Institutes for the successful application of an integrated survey that covers all the Adriatic Sea and for the effort in the improvement of the DEPM method for GSA 18, as well as CopeMed II and the Moroccan and Spanish Institutes that participated in a first attempt to jointly analyse the stocks in the Alborán Sea. The WG recommends that these and other similar initiatives be fully supported by required parties, and encourages the participant Institutes and Countries to perform joint analysis of the available data, especially when evidence of connectivity of stocks, populations or stock units across areas/countries exists. The WG also encourages testing the potential of performing unique joint assessments on shared stocks, and recognizes the importance of spatial issues both for assessment and management of small pelagic fish stocks.

24. Also, the WG acknowledged the importance of strengthening the scientific cooperation towards standardization of echo-survey activities in Mediterranean. This cooperation, which involves North African and European countries, especially those conducting MEDIAS, is going to be facilitated by the FAO Sub-Regional Projects CopeMed II, MedSudMed and EastMed in the ambit of SAC-GFCM activities.

25. The WG welcomes the presentation of a preliminary assessment of sardine in Algerian waters, as well as its collaboration in the joint assessment of shared stocks of pelagic fish in the Alborán Sea. The WG encourages this effort to be continued in the future and hopes that new assessments will be available in next sessions.

Combined GSA 01, GSA 02, GSA 03 and partially GSA 04 - Alboran Sea

Anchovy (*Engraulis encrasiclous*)

Authors: O. Kada, A. Giráldez, J. Settih, Y. Zahri, M.H. Idrissi, S. El Arraf, M. Malouli Idrissi, M. Najih, S. Ben Smail, M. Hachemane, F. Álvarez, M. Bernardon, J.A. Camiñas, I.L. Fernández.

One of the roles of the FAO project is to support the scientific communities in to gather available information on the fisheries to assess the stocks, particularly those shared at least by two countries. CopeMed II emphasis is the reduction of the differences currently existing in the capacity of the participating countries and to promote subregional approach to fisheries research and management. The subregional working groups on Mediterranean shared stocks organized by CopeMed II are of major importance for the reorientation of approaches to stock assessments (moving from single country analysis to joint subregional analysis) and the possibility of the implementation of scientifically based management plans for the fisheries targeting shared stocks at subregional level.

Pelagic species represent an important fishery and economic activity for the countries bordering the Alboran Sea. Among the pelagic species with great importance in terms of both total landings and economic value are sardine (*Sardine pilchardus*) and Anchovy (*Engraulis encrasicolus*), although other species are taking an important percentage in the production and economic value. Anchovy was identified by the experts participating at the CopeMed II meeting on the definition of priority topics related to share resources as priority for the Alboran Sea region. Algeria, Morocco and Spain were identified as countries sharing this possible stock.

Following the recommendations of the 5th meeting of the CopeMed II Coordination Committee, the CopeMed-MedSudMed Subregional Small Pelagic WG, (SRPWG) and the SAC-SCSA requirements, a first meeting of the *CopeMed II Study Group on Engraulis encrasicolus of the Alboran Sea* was organized, involving scientists (biologist and economist) from Algeria, Morocco and Spain and the FAO-CopeMed. With the aim of carrying out a preliminary joint assessment of the stock among Algeria, Spain and Morocco, the identification of a single Anchovy stock in GSAs 01, 02, 03 and 04 and the election of the most appropriate approach and methodology, as a first result of this joint exercise among national research institutions, were discussed.

Information on the fisheries from Algeria, Morocco and Spain was provided to the study group including description of the fisheries targeting Anchovy (fleets components, fishing gears, fishing grounds and periods, landing ports, landing statistics, fishing effort, commercialization and transformation of captures, fleets dynamics and fishing strategies), Data collection systems: frequency and accuracy; Fishery research: Biological sampling of commercial catches; experimental surveys, stock assessment (methods used and results) and Socio-economic available data.

Based on the socio-economic data and information provided to the meeting, experts prepared a joint table with the fleet's characteristics in each country to provide to the three countries with a global vision of the small pelagic fisheries in the Alboran Sea. A total of ten Local Operational Units were identified including its technical characteristics and data on captures, effort and also the crew involved in each unit.

Local Operational Units by country	Nº	Country	GSA	Fleet Segment		Fishing Gear Class	Group of Target Species	N° of boats	Capacity (GT)	Engine power (HP)	Boat size (m)	Catch (T)	Effort (Day/year)	Crew
Spain (2)	1	Spain	1	G	6-12 m	Purse seine	Small pelagic	12	5,19	65,42	9,97		717	
	2	Spain	1	H	12-24 m	Purse seine	Small pelagic	88	26,7	189,4	17,1		7427	
Morocco (4)	3	Morocco	3	G	6-12 m	Purse seine	Small pelagic	9	8,84	105,56		189	264	12
	4	Morocco	3	B	6-12 m	Small scale purse seine	Small pelagic	132	3,75	31,39				10
	5	Morocco	3	H	12-24 m	Purse seine	Small pelagic	109	49,06	330,7		12991	7739	31
	6	Morocco	3	H	>24 m	Purse	Small	4	86	525		492	270	43

						seine	pelagic							
Algeria (4)	8	Algeria	4	G	6-12 m	Purse seine	Small pelagic	6	14	152	9,5		270	10
	9	Algeria	4	H	12-24 m	Purse seine	Small pelagic	119	32,77	308,84	15,69	4968	1444	20
	10	Algeria	4	J	12-24 m	Pelagic trawler	Small pelagic	38	63,4	518,0	20,7		1332	10
	11	Algeria	4	J	>24 m	Pelagic trawler	Small pelagic	7	114	870	26	1382	756	10

Table. 1 ***The small pelagic fleet segments operating in the Alboran Sea (CopeMed II, 2012)***

The Study Group was aware of the lack of biological and fisheries data presented to the meeting, mainly from Morocco and Algeria, and of the impossibility to conduct a general analysis of the state of the stock of Anchovy in the GSAs 01, 03 and 04. In order to carry out a joint assessment next year, the SG recommended a bigger effort in Algeria and Morocco to facilitate the data and existing information of the national fisheries targeting Anchovy to the experts of the CopeMed SG.

Results, conclusions and recommendations: The SG recommended that a monitoring system for small pelagic fishing activity should be implemented in the main ports of the Algerian Alboran Sea or at least in the most representative. The Anchovy fishery should be regularly sampled and a monitoring system should be strengthened especially to obtain size distributions at landing and biological parameters.

The SG recommended that in Morocco, Anchovy fishery in the Mediterranean should be taken into account in the actual system of fishing activity monitoring. For socio-economic aspects, specific surveys are necessary.

In the framework of the EAF management of sardine and Anchovy in the Alboran Sea, the SG considered that bio-economic modelling is an adequate tool for producing scientific recommendations. Therefore, socioeconomic experts recommended continuing with the initiated work on socio-economic indicators in the three countries (joint data preparation and validation of the methodology) to prepare joint advice.

Combined GSA 01 and GSA 03 - Alboran Sea

Sardine (*Sardina pilchardus*)

Authors: Omar Kada, M.H. Idrissi, A. Giraldez

Small pelagic resources and particularly sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicholus)* represent an important fishery activity for the countries bordering the Alboran Sea.

With the indispensable support of CopeMed II, a new meeting of the subregional working group on small pelagic species was carried out in Nador (Morocco). This study group was organized with the participation of experts from Spanish, Moroccan and Algerian research institutes aiming to do a new exercise on sardine stock considered a share stock. The medium term objective is to better manage fisheries resources in the Alboran Sea area.

After discussion of the main fisheries and species targeted in the countries the subregional working group on small pelagic in GSA 01, 02 and 03 agreed in starting by the compilation and analysis of the data concerning sardine and anchovy. The comparison of data exists on the geographical distribution of the sardine in GSA 01 and GSA 03, data on the evolution of catches and also on the size structure of exploited populations of this species was carried out.

A comparative analysis on sardine landing series from Morocco and Spain from 2003-2011 in GSA01 and GSA03 was carried out. The result of the analysis explaining that the exploitation pattern in both sub-areas (GSAs 01 and 03) is different but the total length-frequency distribution exploited by each fleet is similar.

Thus, experts from both countries Spain and Morocco have conducted a joint exercise to estimate the status of sardine stock in the Alboran Sea supposedly shared. Preliminary results of this exercise were achieved, and presented to the SCSA small pelagic working group in Split (Croatia) meeting.

This joint analysis of data from GSA01 and GSA03 shows that the fishing effort in both countries is focused mainly on adult's ages 3 and 4.

The yield per recruit analysis indicates that the sardine stock in the Alboran Sea (GSA01 and GSA03) is in a state of overexploitation, with a value of biological reference point located: $F0.1 = 0.68$. However, missing data are related to the Algerian part of the Alboran Sea (western part of GSA04), data that could better accurately the situation of the sardine stock in the Alboran Sea.

The average operating E is estimated at 0.43 (slightly higher than the threshold value $F / Z = 0.4$ as suggested biological reference point for small pelagic (Patterson, 1992)). Thus, the exploitation rate can be considered as high.

From a methodological point of view and to ensure the correct approach to this joint analysis and make data comparable, experts from the two countries agreed on the need to continue with improving the standardization of methodologies for biological sampling and analysis techniques for small pelagic.

The Cope Med sub regional working group proposed the standardization and calibration even for acoustic methodology for direct assessment of sardine in the Alboran Sea area. With this objective in mind the experts proposed the possibility of carrying out acoustic surveys by each country during the same periods of the year in order to enable comparison of results of each country or alternatively organize a joint acoustic survey for the whole Alboran Sea (GSAs 01, 02, 03 and western part of GSA 04).

In order to continue improving the assessment of the stock of Sardine, the WG recommend that CopeMed II may support the organization of a new meeting of the sub regional working group in 2013 keeping the dates of this year and added Algerian data (GSA04).

GSA 04 - Alboran Sea

Sardine (*Sardina pilchardus*)

Authors: S. Ben Smail

In this stock assessment exercice, preliminary results show **full exploitation** for the sardine stock in the Algerian part of the Alboran Sea. Once the exploitation indicators as CPUE, Effort and landings show a decrease trend of this species.

By lack of a historical biological data for a stock assessment of this species, and by precautionary approach, this result must remain preliminary and need further discussion until to complete the data.

Two different models were presented during the WG, i.e. a Shaefer model and a preliminary length cohort analysis with VIT. The resulting picture was slightly different between the two approaches: the stock is overexploited with the Shaefer model and it's fully exploited with VIT model. Therefore, the assessesment is considered as a preliminary one, and no conclusions were reached during this WG *.

* The WG received a new individual report for this stock after the meeting, on which conclusions were based uniquely on the VIT assessment. This report is expected to be reviewed on the Subcommittee on Stock Assessment and on next year meeting of the WG.

GSA 07 - Gulf of Lion

Sardine (*Sardina pilchardus*)

Authors: J-L. Bigot, J-H. Bourdeix, D. Roos, C. Saraux

Fisheries:

Both pelagic trawlers and purse seines are present in the Gulf of Lions. However, the number of boats has been decreasing these last few years and the French fleet now contains 7 trawlers and 3 purse-seines targeting sardines. As a consequence, the total catches have also been decreasing and are now reaching very low levels (less than 800 T). Most regulations (no fishing activity during the week-end, length of trawlers, etc.) are fully respected, the limitation of engine power for trawlers being the only one not to.

Data and parameters

Morphometric parameters were obtained directly onboard during the scientific survey, while samples were taken back to the lab for age determination and reproductive parameter analysis. Length-weight relationships were thus obtained. Biological indices such as size distribution of the population, growth rate, and size at first maturity have decreased both significantly and rapidly these last 4 to 5 years.

Assessment method: Direct method by acoustics

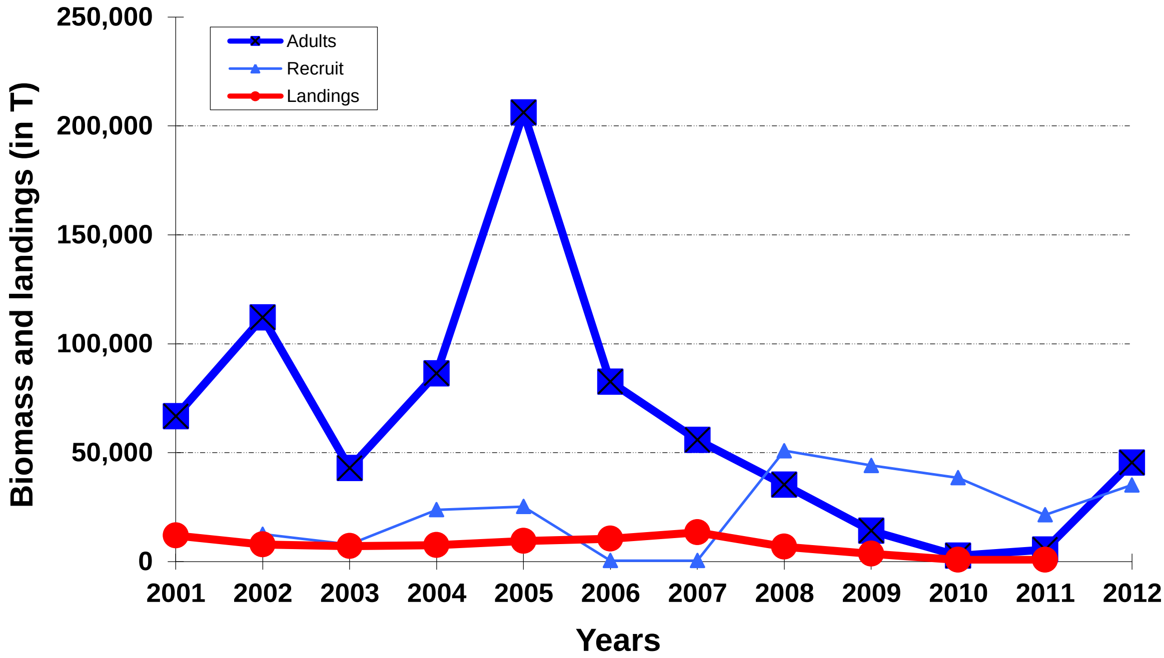
Sampling was performed in July along 9 parallel and regularly interspaced transects (inter-transect distance = 12 nautical miles). Acoustic data were obtained by means of echosounders

(Simrad ER60) and recorded at constant speed of 8 nm.h^{-1}. The size of the elementary distance sampling unit (EDSU) is 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output. Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a 30 min-trawl at 4 nm.h^{-1} in order to evaluate the proportion of each species (by randomly sampling and sorting of the catch before counting and weighing each individual species). A total of 37 trawls were conducted. While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminarily treated with Movies + software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts.

Results

	Biomass in metric tons	fish numbers
Sardines	80 537	9 370.835 million
Anchovies	39 061	5 142.302 million
Sprat	70 263	14 649.016 million

According to a revised age-length key, sardines were separated between adults (45 352 T) and recruits (35 184 T).



Diagnose of Stock status:

Exploitation rate		**Stock Abundance**	
1993-2012		1993-2012	
	No fishing mortality		Virgin
X	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality	X	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		**Recruitment trends**	
1993-2012		1993-2012	
	Stable		Stable
	Increasing	X	Increasing
X	Decreasing*		Decreasing

*2012 exhibits a higher biomass that if confirmed in the following years could reverse the trend to a positive one.

Advice and recommendation:

Generally for these last 4 to 5 years, we had been observing very low and depleted adult (age 1+) biomass, contrasting with the high recruitment. This may suggest an important external spawning biomass contribution to the GSA07 stock or a very high adult mortality or migration right after first reproduction. At the same time, complementary biological indices such as size distribution of the population, growth rate, and size at first maturity decreased both significantly and rapidly, more indications of a stock in a poor state trying to adapt by modifying its life-history traits. Also, it should be noted that the GSA07 system has been showing important changes in the structure of the main stocks of sardines and anchovies with an unusually high abundance of sprats, so that the total number of fish from these 3 species is very high suggesting possible carrying capacity limit. Finally, the fleet did not manage to capture any significant amounts of sardine in the last few years, and the commercial activity has almost stopped since the end of 2009.

This year, for the first time, we observed an increase both in the total biomass and in the adult biomass. This may be the first signs of a recovery in the stock, but they need to be confirmed both by biological parameters and abundance trends in the future years. Besides, recruitment level remains high as in the past 5 years. Yet, it should be noted that the length-based separation between adults and recruits has been modified this year (12 cm instead of 13 cm) due to the observed changes in growth patterns and length distribution of the population.

Because these are the first positive signs for the stock and because we have not yet observed any improvement in the biological parameters, we would recommend not to increase fishing effort (the fishing effort is already very low) to allow the stock to recover, by preventing additional sources of mortality to this still fragile stock.

GSA 07 - Gulf of Lion

Anchovy (*Engraulis encrasicolus*)

Authors: J-L. Bigot, J-H. Bourdeix, D. Roos, C. Saraux

Fisheries:

Both pelagic trawlers and purse seines are present in the Gulf of Lions. However, the number of boats has been decreasing these last few years and the French fleet now contains 15 trawlers and 3 purse-seines targeting anchovies and sardines at the same time. In 2011, only 10 trawlers regularly caught anchovies and the three purse-seines fished only part of the year (2, 3 and 5 months for the three boats). As a consequence, the total catches have also been decreasing with less than 2000 T caught. Most regulations (no fishing activity during the week-end, length of trawlers, etc.) are fully respected, the limitation of engine power for trawlers being the only one not to.

Data and parameters

Morphometric parameters were obtained directly on board during the scientific survey, while samples were taken back to the lab for age determination and reproductive parameter analysis. Length-weight relationships were thus obtained. Growth and length at first maturity have been decreasing during the past few years.

Assessment method: Direct method by acoustics

Sampling was performed in July along 9 parallel and regularly interspaced transects (inter-transect distance = 12 nautical miles). Acoustic data were obtained by means of echosounders (Simrad ER60) and recorded at constant speed of 8 $nm.h^{-1}$. The size of the elementary distance sampling unit (EDSU) is 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output. Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a 30 min-trawl at 4 $nm.h^{-1}$ in order to evaluate the proportion of each species (by randomly sampling and sorting of the catch before counting and weighing each individual species). A total of 37 trawls were conducted. While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminarily treated with Movies + software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts.

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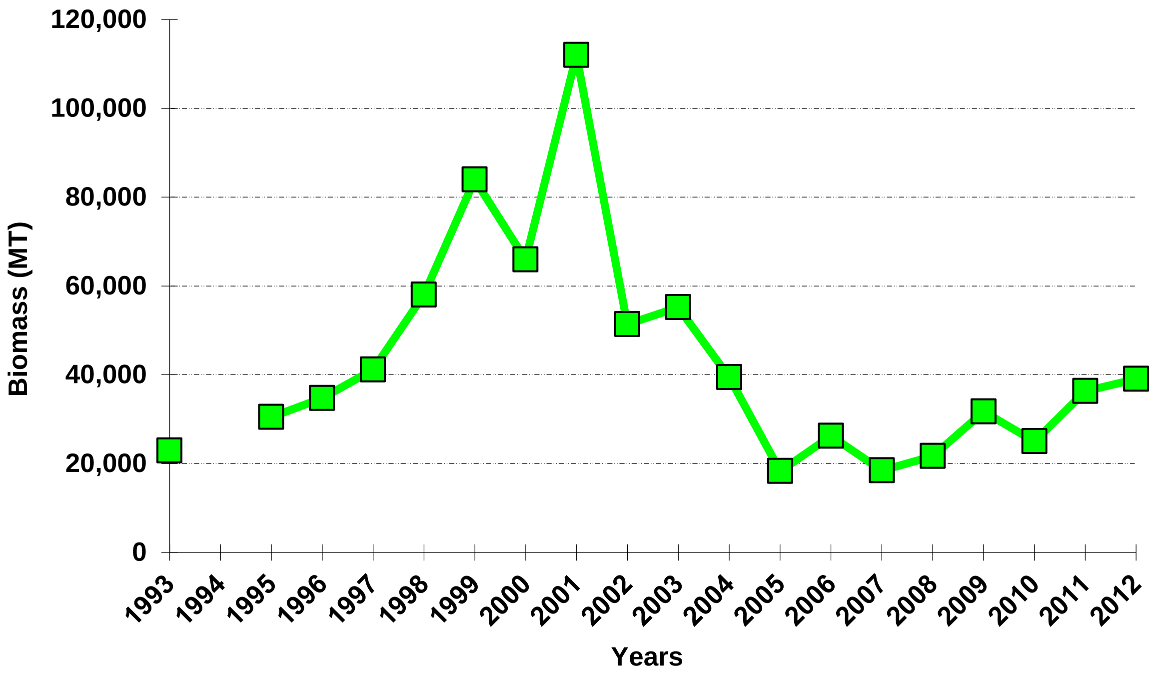
Anchovies	39 061	5 142.302 million
Sprat	70 263	14 649.016 million



Diagnose of Stock status:

Exploitation rate		Stock Abundance	
1993-2012		1993-2012	
	No fishing mortality		Virgin
X	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality	X	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1993-2012		1993-2012	
x	Stable		Stable
	Increasing		Increasing
	Decreasing		Decreasing

Advice and recommendation:

The total biomass of anchovies appears to have been quite stable (with even a slight increasing tendency) in GSA07 for the last 8 years. Yet, the stock remains quite unbalanced with a very low abundance of commercial sizes of anchovy (age group of 1+). Further, the mean size observed in anchovies was appreciably below the values usually found for this stock. Therefore, we advise not to increase fishing effort to avoid increasing the pressure on the few adults. Finally, it should be noted that the GSA07 system has been showing important changes in the structure of the main stocks of sardines and anchovies with an unusually high abundance of sprats, so that the total number of fish from these 3 species is very high suggesting possible carrying capacity limit.

GSA 16 – Southern Sicily

Sardine (*Sardina pilchardus*)

Authors: B. Patti, E.M. Quinci, A. Bonanno, G. Basilone, S. Mazzola

Fishery:

In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port (accounting for about 2/3 of total landings): purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. In both OUs, anchovy represents the main target species due to the higher market price. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped.

Average sardine landings in Sciacca port over the period 1998-2011 were about 1,400 metric tons, with a general decreasing trend. The production dramatically decreased in 2010 (-70%), but increased again above the average in 2011. Fishing effort remained quite stable over the last decade. Sardine biomass, estimated by acoustic methods, ranged from a minimum of 6,000 tons in 2002 to a maximum of 39,000 tons in 2005. Current (2011) acoustic biomass is at intermediate level.

Data and parameters:

Landings data for GSA16 were obtained from DCF for the years 2006-2011 and from census information (on deck interviews) in Sciacca port (1998-2011). Acoustic data were used for fish biomass evaluations over the period 1998-2011. Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2008. Natural mortality was estimated following Pauly (1980) and by the Beverton & Holt's Invariants (BHI) method (Jensen, 1996). For the BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and $k = 0.40$.

The input data used for the stock was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2011. Available data were used to estimate yearly and average (2007-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey), and as input for the fitting of a non-equilibrium surplus production model.

The scientific surveys, mainly carried during early summer of each year, were considered to represent the stock abundance the same year including part of the recruitment. In addition, an enviromental index, the satellite-based estimate of yearly average chlorophyll-a concentration over the continental shelf off the southern sicilian coast, was used in the attempt of improving the performance of the model fitting.

Assessment method:

Two separate approaches were adopted:

- An empirical approach bassed on estimation of yearly and average (2008-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey);
- A modelling approach based on thefitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indeces, allowing for the optional incorporation of environmental indices, so that the *r* and/or *K* parameters of each year can be considered to depend on the corresponding value of the applied index.

The first approach for the evaluation of stock status is based on the analysis of the harvest rates experienced in the available time series over the last years and on the related estimate of the current exploitation rate. Actually, as long as this estimate of harvest rate can be considered as a proxy of F obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can also be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given. Sardine biomass estimates are based on acoustic surveys carried out during the summer and, as in general they would include the effect of the annual recruitment of the population, they are possibly higher than the average annual stock sizes. This in turn could determine in an underestimation of the harvest rates and of the corresponding exploitation rates.

The modellig approach uses four basic parameters: Carring capacity (or Virgin Biomass) K, population intrinsic growth rate r, initial depletion BI/K (starting biomass relative to K) and catchability q (fixed). Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the overall MSY, B_{MSY} and F_{MSY} reference points. Derived reference points were also evaluated: B_{Cur}/B_{MSY}, indicating whether the estimated stock biomass, in any given year, is above or below the biomass producing the MSY, and F_{Cur}/FSY_{Cur} (the ratio between the fishing effort in the last year of the data series and the effort that would have produced the sustainable yield at the biomass levels estimated in the same year), indicating whether the estimated fishing mortality, in any given year, is above or below the fishing mortality producing the sustainable (in relation to natural production) yield in that year.

Model performance:

Quite poor (R^2 = 0.35) without incorporating environmental effects, quite good (R^2 = 0.76) when adopting in the model formulation a variable carrying capacity, considered to be positively affected by chlorophyll-a concentration at sea (exponential effect).

Results:

Annual harvest rates, as estimated by the ratio between total landings and stock sizes, indicated relatively low fishing mortality during the last decade. The current (year 2011) harvest rate is 11.9% (DCF data were used for landings). The estimated average value over the years 2008-2011 is 13.7%.

The exploitation rate corresponding to F=0.137 is E=0.15, if M=0.77, estimated with Pauly (1980) empirical equation, is assumed, and E=0.16 if M=0.72, estimated with Beverton & Holt’s Invariants method (Jensen, 1996), is used instead. In relation to the above considerations on the possible overestimation of mean stock size in harvest rate calculation, it is worth noting that, even if the harvest rates were twice the estimated values, the exploitation rates would continue to be lower than the reference point (0.4) suggested by Patterson (1992). Thus, using the exploitation rate as a target reference point, the stock of sardine in GSA 16 would be considered as being sustainably exploited.

The results of the second assessment approach, which is based on the implementation of a non-equilibrium logistic surplus production model, are consistent with the previous considerations about trends in harvest rates and in estimated exploitation rates.

The fluctuations in stock biomass cannot be explained solely by the observed fishing pattern. This was an expected result, as pelagic stocks are known to be significantly affected by environmental variability. The incorporation of an environmental index in the model, significantly improved the fitting of the model, allowing the stock to grow more or less than average depending on the state of the environment in each year.

In the current adopted formulation of the model, satellite-based data on chlorophyll concentration showed to have a positive effect on the yearly carrying capacity. The current (year 2011) fishing mortality is below the sustainable fishing mortality at current biomass levels (F_{Cur}/FSY_{Cur}=0.69) but slightly above F_{MSY} (F_{MSY}=0.16; F_{Cur}/F_{MSY}=1.05) (Table 1), and fishing mortality experienced high values during the considered period, sometimes above sustainability (F_{Cur}/FSY_{Cur}>1). In addition abundance was low over the last decade (B/B_{MSY} < 50%; B_{MSY} = 32527; B_{Cur}/B_{MSY} = 0.48). However, the average production of the last three years (1400 tons) is well below the estimated MSY (5307 tons).

Table GSA16_pil_1: Reference points

MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
5307	32527	0.16	48%	69%	105%

Diagnose of Stock status:

The present diagnosis of stock status is based on the evaluation of current exploitation pattern and biomass levels. The adopted reference points (RP) for fishing mortality were E=0.4 (Patterson) and F_{MSY}, whereas for biomass level the WG proposed the use of both B_{MSY} and a new set of RP, B_{lim} and B_{pa}, as defined below.

Results of the adopted modelling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels (mostly due to recruitment success) and indicate that from year 2000 onward the stock status was well below the B_{MSY}.

In addition, the stock in 2010-2011 only partially recovered from the high decrease in biomass occurred in 2006 (-52% from July 2005 to June 2006), and this fact, along with the general decreasing trend in landings over the last decade, also suggests questioning about the sustainability of current levels of fishing effort.

A tentative B_{lim} was discussed and adopted by the WG as the lowest value observed in the last year of the series. Similarly, B_{pa} was established as B_{lim}*1.4.

Using the above reported RP, the current biomass estimate (14977 tons, 2011 value) is well below B_{MSY} (32527 tons), but above the adopted estimated B_{lim} (8028 tons) and also above B_{pa} (11239 tons) (see Figure 1)

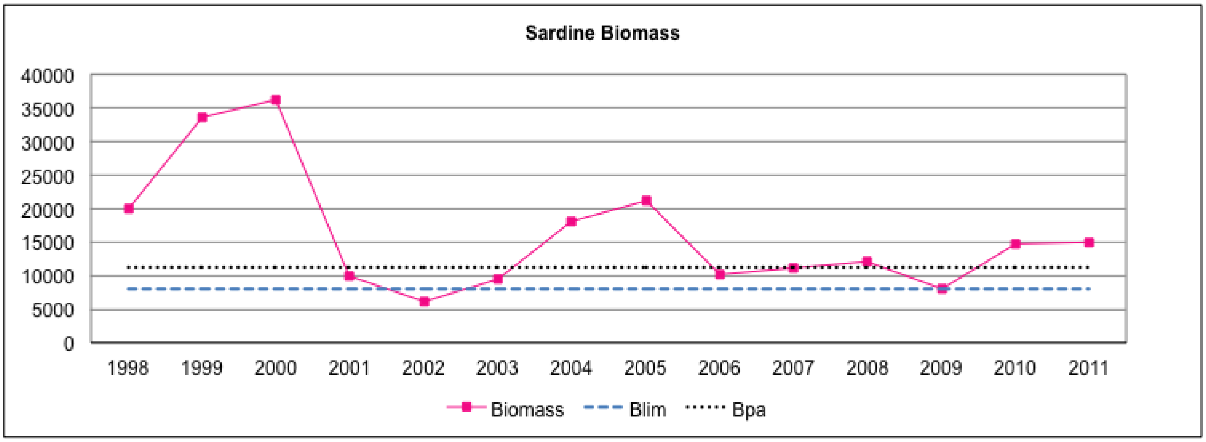


Figure GSA16_pil_1: Trends in sardine biomass (tons), years 1998-2011. Blim and Bpa are also indicated

Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
1998-2011		1998-2011	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
X	Sustainable Fishing Mortality	**X**	Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
1998-2011		N.A.	
6000-36370 tons		[Range]	
	Stable		Stable
	Increasing		Increasing
X	Decreasing		Decreasing

Advices and recommendations:

Given that the stock biomass over the last years appears to be in a stable low abundance phase respect to B_{MSY} and considering the fishing mortality pattern observed throughout the time series, fishing effort should not be allowed to increase and consistent catches should be determined. However, as the small pelagic fishery is generally multispecies, any management of fishing effort targeting the sardine stock would also have effects on anchovy. Local small pelagic fishery appears to be able to adapt at resource availability and market constraints, targeting the fishing effort mainly on anchovy. But due to the generally low biomass levels experienced by the anchovy stock over the last years (see related assessment), measures should be taken to prevent a possible further shift of effort back from anchovy to sardine.

GSA 16 – Southern Sicily

Anchovy (*Engraulis encrasicolus*)

Authors: B. Patti, E.M. Quinci, A. Bonanno, G. Basilone, S. Mazzola

Fishery:

In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port: purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. In both OUs, anchovy represents the main target species due to the higher market price. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped.

Average anchovy landings in Sciacca port over the period 1998-2011 were about 2,000 metric tons, with large interannual fluctuations. Fishing effort remained quite stable over the last decade. Anchovy biomass, estimated by acoustic methods, ranged from a minimum of 3,100 tons in 2008 to a maximum of 23,000 tons in 2001. Current (2011) acoustic biomass estimate is below the average over the considered period (5,070 vs. 11,105).

Data and parameters:

Landings data for GSA16 were obtained from DCF for the years 2006-2011 and from census information (on deck interviews) in Sciacca port (1998-2011). Acoustic data were used for fish biomass evaluations over the period 1998-2011. Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2009. Natural mortality was estimated following Pauly (1980) and by the Beverton & Holt's Invariants (BHI) method (Jensen, 1996). For the BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and $k = 0.31$.

The input data used for the stock was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2011. Available data were used to estimate yearly and average (2007-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey).

The scientific surveys, mainly carried during early summer of each year, were considered to represent the stock abundance the same year. In addition an enviromental index, the satellite based estimate of yearly average chlorophyll-a concentration over the continental shelf off the southern sicilian coast, was used in the attempt of improving the performance of the model fitting.

Assessment method:

Two separate approaches were adopted:

- An empirical approach bassed on estimation of yearly and average (2007-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey);

- A modelling approach based on thefitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indeces, allowing for the optional incorporation of environmental indices, so that the *r* and/or *K* parameters of each year can be considered to depend on the corresponding value of the applied index.

The first approach used herewith for the evaluation of stock status is based on the analysis of the harvest rates experienced in the available time series over the last years and on the related estimate of the current exploitation rate. Actually, as long as this estimate of harvest rate can be considered as a proxy of F estimate obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given.

The modelling approach uses four basic parameters: Carring capacity (or Virgin Biomass) K, population intrinsic growth rate r, initial depletion BI/K (starting biomass relative to K) and catchability q (fixed). Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the overall MSY, B_{MSY} and F_{MSY} reference points. Derived reference points were also evaluated: B_{Cur}/B_{MSY}, indicating whether the estimated stock biomass, in any given year, is above or below the biomass producing the MSY, and F_{Cur}/FSY_{Cur} (the ratio between the fishing effort in the last year of the data series and the effort that would have produced the sustainable yield at the biomass levels estimated in the same year), indicating whether the estimated fishing mortality, in any given year, is above or below the fishing mortality producing the sustainable (in relation to natural production) yield in that year.

Model performance:

Quite poor (R^2 = 0.11) without incorporating environmental effects, significantly higher (R^2 = 0.45) when adopting in the model formulation a variable population intrinsic growth rate *r*, considered to be positively affected by chlorophyll-a concentration at sea (exponential effect).

Results:

The high and increasing yearly harvest rates, as estimated by the ratio between total landings and stock sizes, indicate high fishing mortality levels. The current (year 2011) harvest rate is 79.3% (DCF data were used for landings). The estimated average value over the years 2008-2011 is again 79.3%. The exploitation rate corresponding to F=0.79 is E=0.55, if M=0.66, estimated with Pauly (1980) empirical equation, is assumed, and E=0.59 if M=0.56, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. Consequently, sing as reference point for the exploitation rate the 0.4 value suggested by Patterson (1992), this stock should be considered as being overexploited.

The results of the second assessment approach, which is based on the implementation of a non-equilibrium logistic surplus production model, are consistent with the previous considerations about trends in harvest rates and in estimated exploitation rates. The fluctuations in stock biomass cannot be explained solely by the observed fishing pattern. This was an expected result, as pelagic stocks are known to be significantly affected by environmental variability. The incorporation of an environmental index in the model significantly improved the fitting of the model, allowing the stock to grow more or less than average depending on the state of the environment in each year. In the current adopted formulation, satellite-based data on chlorophyll concentration showed to have a positive effect on the yearly population intrinsic growth rate. Current (year 2011) fishing mortality is far above the sustainable fishing mortality at current biomass levels_(F_{Cur}/FSY_{Cur}=3.15; F_{MSY}=0.17; F_{Cur}/F_{MSY}=4.54; see Table 1). Fishing mortality experienced very high values during the considered period, frequently well above sustainability (F_{Cur}/FSY_{Cur}>1). In addition, B_i/B_{MSY} values were below 100% over the entire time series (B_{MSY} = 14152 tons; B_{Cur}/B_{MSY} = 0.56), and estimated average production of the last three years (5160 tons) is well above the MSY (2359 tons).

Table GSA16_anc_1: Reference points

MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
2359	14152	0.17	56%	315%	454%

Diagnose of Stock status:

The present diagnosis of stock status is based on the evaluation of current exploitation pattern and biomass levels. The adopted reference points (RP) for fishing mortality were E=0.4 (Patterson) and FMSY, whereas for biomass level the WG proposed the use of both B_{MSY} and a new set of RP (B_{lim} and B_{pa}) as defined below.

Results of the adopted modeling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels and indicate that the stock abundance was below the B_{MSY} during the last years.

In addition, fishing levels over the last years are increasing and higher than those required for extracting the MSY of the resource.

A tentative B_{lim} was discussed and adopted by the WG as the lowest value observed in the last year of the series. Similarly, B_{pa} was established as B_{lim}*1.4.

Using the above reported RP, the current biomass estimate (5070 tons, 2011 value) is well below B_{MSY} (14152 tons), but it is above the adopted estimated B_{lim} (3130 tons) and also slightly, even not significantly, above B_{pa} (4382 tons) (Fig. 1).

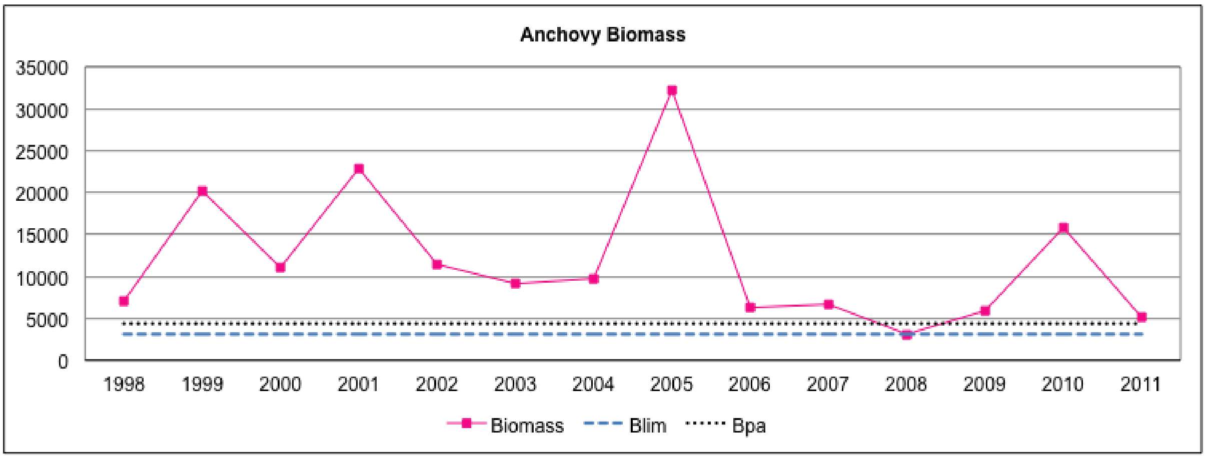


Figure GSA16_anc_1: Trends in anchovy biomass (tons), years 1998-2011. Blim and Bpa are also indicated

Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
1998-2011		1998-2011	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
X	High fishing mortality	**X**	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
1998-2011		N.A.	
6000-36370 tons		[Range]	
	Stable		Stable
	Increasing		Increasing
X	Decreasing		Decreasing

Advices and recommendations: (in terms of research and, when possible in terms of management)

Given that the stock is currently overexploited, fishing effort should be reduced by means of a multi-annual management plan until there is evidence for stock recovery. Consistent catch reductions along with effort reductions should be determined. However, the mixed fisheries effects, mainly the interaction with sardine, need to be taken into account when managing the anchovy fishery. As the small pelagic fishery is generally multispecies, any management of fishing effort targeting the anchovy stock would also have effects on sardine. Local small pelagic fishery appears to be able to adapt at resource availability and market constraints, targeting the fishing effort mainly on anchovy. But due to the low biomass levels experienced by the anchovy stock over the last years, measures should be taken to prevent a possible further shift of effort back from anchovy to sardine.

GSA 17 – Northern Adriatic Sea

Sardine (*Sardina pilchardus*)

Authors: P. Carpi, S. Angelini, A. Belardinelli, I. Biagiotti, F. Campanella, G. Canduci, N. Cingolani, V. Čikeš Keč, S. Colella, C. Croci, A. De Felice, F. Donato, I. Leonori, M. Martinelli, S. Malavolti, T. Modic, M. Panfili, P. Pengal, A. Santojanni, V. Ticina, C. Vasapollo, B. Zorica, E. Arneri

Fishery

Sardines are fished by purse seiners, attracting fish by light and pelagic trawlers belonging to Italy, Croatia and Slovenia. The fishery takes place all year round: a closure period is observed from the Italian pelagic trawlers on August, while from 15th December to 15th January in Croatia. In 2011 the closure season for the Italian fleet was extended to 60 days (August and September).

Exploitation is based on all the age classes from 0 to 6+.

The Croatian catches of sardine represent the great part of the total catches, while the Italian small pelagic fishery concentrate mainly on anchovy (though high amounts were caught by the Italian fleet in the past).

The Italian fleet is composed of about 65 pairs of mid-water trawlers and about 45 purse seiners (with quite different tonnage), with the former being predominant on the latter ones.

In Croatia, small pelagic (mainly sardine) are fished by purse seiners. In 2011 Slovenia had 5 actively fishing purse seiners and one active pair of pelagic trawlers.

Data and parameters

The data used for the present assessment derive from the catch recorded for the fleets of Italy, Croatia and Slovenia, from 2000 to 2011. The biological data of the species (available since 1975 for the western and from the 2001 for the eastern side) were used to obtain the age distribution in the catches. The period covered by the present assessment goes from 2000 to 2011.

Echo-survey abundance index was used to tune the models. The echo-surveys were carried out for both the western and eastern sides from 2004 onwards. Western echo-survey abundances were split into age classes by the means of length frequency distribution and age-length key coming from the western echo-survey. On the other hand, eastern echo-survey biomass was distributed into age classes by the means of proportion at length from the 2009 eastern echosurvey and age-length keys from the Croatian commercial fleet.

The 2011 eastern echo-survey covered only about 50% of the total area: for this reason, an average percentage of the biomass in that area from the previous years (2004-2010) was applied.

Also, this year for tuning the assessment we used an index of biomass for sardine from 2000 to 2011 coming from bottom trawl survey (MEDITS). Since trawl survey target demersal species, weight for this tuning index was lower (0.3) than the one for echo-survey (1.0).

Calendar year was used, by fixing the birthday date on the first of January, according to the biology of this species in the Adriatic Sea.

The natural mortality rate M was taken as variable over age and was calculated using the Gislason's equation. The growth parameters required by this method were derived from Sinovcic (1984).

Assessment method

Integrated Catch Analysis (ICA) and Virtual Population Analysis (VPA) with Laurec-Shepherd tuning.

Model performance

The ICA model performed well with the data available: the marginal totals of residuals between the catch and the separable model are overall small, as well as reasonably trend-free in the separable period (2005-2011), but for a small degree of year effect. The CVs are on the overall lower than 20%. There is some degree of retrospective pattern, especially for the years 2009-2010, which will be investigated.

The VPA model gave similar results in terms of biomass, but the standard error for the q estimates are a little bit higher than the suggested 0.5. The restrospective pattern is lower than in the ICA.

The age class 0 was not included into the analysis since the value of M = 2.51 obtained for this age class would have implied too high and thus not conservative estimates of abundance at sea; also, the age class 0 is not substantial in the total catch at age.

Results

The trend in biomass of sardine obtained by both ICA and VPA started a slow but continuous increase since 2000. The 2011 biomass estimation showed rather high values, the VPA estimation (B = 483369 t) being much higher than the ICA one (B = 215050 t). The current biomass is above the proposed reference points B_{lim} and B_{pa}.

The fishing mortality starts to increase in 2007 for all the ages: in ICA age 4 seems to suffer more from the fishing mortality. The $F_{bar(1-4)}$ reaches the maximum in 2011, being equal to 1.11.

The recent exploitation rate $F/Z_{(1-4)}$ is above the Patterson's threshold 0.4 since 2009, and increased up to 0.52 in the last year due to the high catches. The catch ratio, instead, started to increase in 2005 up to a value around 0.25 in 2009, but it's stable since then.

Diagnose of Stock status

The present status of the stock up to 2011 can be described with high fishing mortality ($E_{(1-4)}$ = 0.52 bigger than RP (E = 0.4)) and intermediate abundance (Current biomass = 215050 tons higher than the proposed B_{lim} (78000 tons) and B_{pa} (109200 tons) reference points).

Advices and recommendations

Although exploitation level is above Patterson threshold of 0.4, the harvest rate considering the ICA model is stable since 3 years around 0.25, while if we take into account the biomass estimated from the echosurvey, the harvest rate drops below 0.15. Besides, biomass level as well as recruitment level showed a steep increase in the last year. Because of that there are no sign that the stock of sardine in the Adriatic Sea is suffering for this high fishing mortality.

Nevertheless, since this stock can display large fluctuations associated with analogous fluctuations in recruitment, the advice is not to increase the fishing effort. Besides, since numerous studies have shown that the dynamics of anchovy and sardine populations are strongly influenced by success in the recruitment, which is, on the other hand, strongly influenced by environmental conditions, the working group suggests continuing to explore the relationships between these species and the environment.

WG recognised that spatial distribution of shared stock of sardine is not limited to GSA17 area only, but it is extended in GSA18 area also. Therefore, WG suggest that future assessments try to take into account combined data from these two GSAs. Moreover, an important nursery area of this stock is located in Gulf of Manfredonia (GSA18) where the sardine stock used to be exploited by fry fishery (the fishery was closed in June 2010).

Fig. GSA_17_pil_1: Mid year stock biomass and proposed reference points.

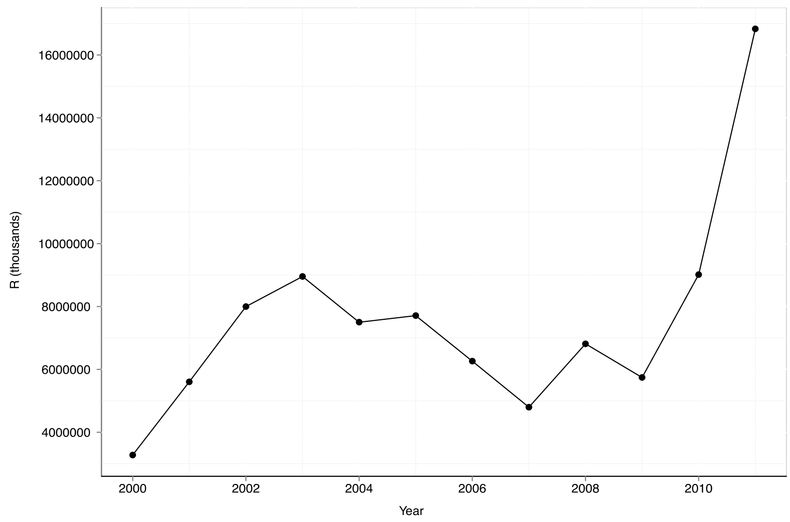


Fig. GSA_17_pil_2. Recruitment estimates (in thousands).

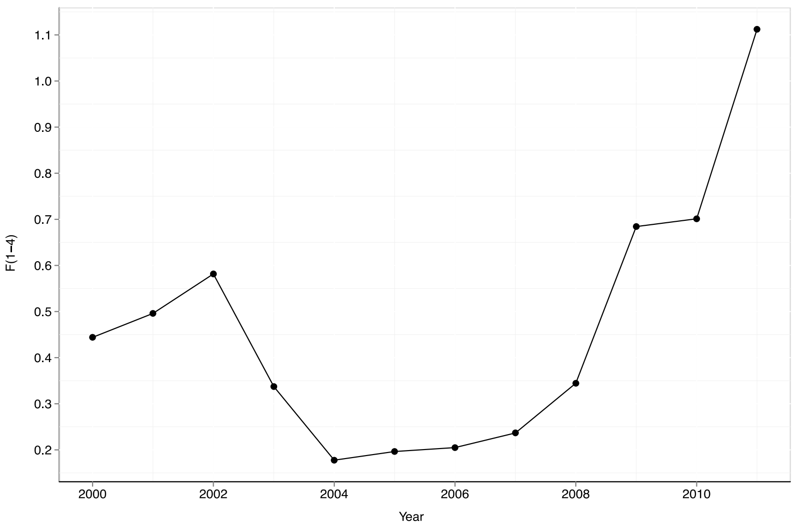


Fig. GSA_17_pil_3: Fbar(1-4) estimates.

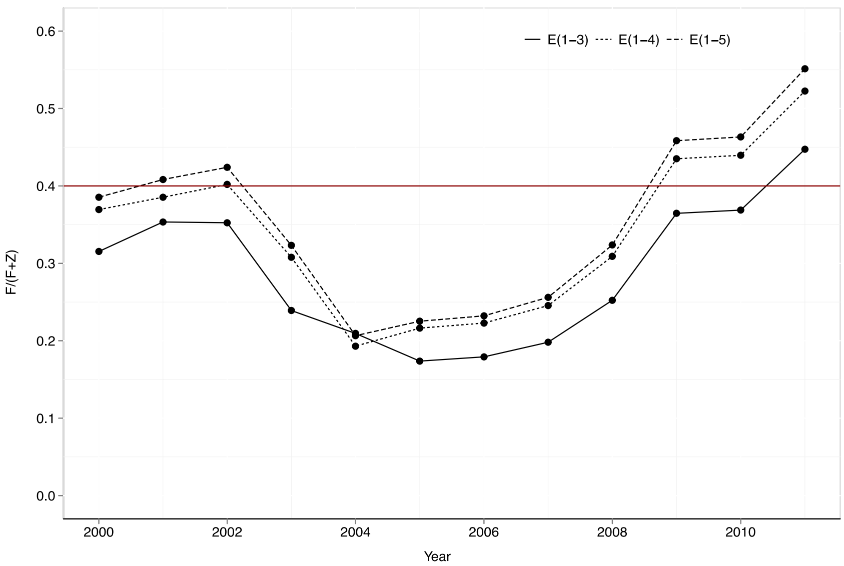


Fig. GSA_17_pil_4: Exploitation rate (F/Z).

Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
[2000-2011]		[2000-2011]	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality	X	Intermediate abundance
X	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
[2000-2011]		[2000-2011]	
[78183 tons-215050 tons]		[3276600 – 16830000 thousands]	
	Stable	X	Stable
X	Increasing		Increasing
	Decreasing		Decreasing

Discussion

It should be noted that Adriatic small pelagic fishery is multispecies and effort on sardine stock cannot be separated from effort on stock of anchovy. Hence, management decisions have to be taken considering both species.

The approach used in this assessment was to maintain the independence of the dataset during the preparation of the input data in order to reduce the statistical dependence (Cotter et al., 2004): the working group tried, whenever possible, to treat echo-survey data as more independent as possible from the commercial data.

Since it’s the first time that biomass reference points are proposed for this stock, and since they were proposed based on the time series assessed, they should be revised in three years, when new data will be available.

GSA 17 – Northern Adriatic Sea

Anchovy (*Engraulis encrasicolus*)

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Fishery

Anchovies are fished by purse seiners, attracting fish by light, and pelagic trawlers belonging to Italy, Croatia and Slovenia. The fishery takes place all year round: a closure period is observed from the Italian pelagic trawlers on August, while from 15th December to 15th January in Croatia. In 2011 the closure season for the Italian fleet was extended to 60 days (August and September).

Exploitation is based on all the age classes from 0 to 4+.

The Croatian catches of sardine represent the great part of the total catches, while the Italian small pelagic fishery concentrate mainly on anchovy (though high amounts were caught by the Italian fleet in the past).

The Italian fleet is composed of about 65 pairs of mid-water trawlers and about 45 purse seiners (with quite different tonnage), with the former being predominant on the latter ones.

In Croatia, small pelagic (mainly sardine) are fished by purse seiners. In 2011 Slovenia had 5 actively fishing purse seiners and one active pair of pelagic trawlers.

Data and parameters

The data used for the present assessment derive from the catch recorded for the fleets of Italy, Croatia and Slovenia, from 2000 to 2011. The biological data of the species (available since 2000 for the western and from the 2001 for the eastern side) were used to obtain the age distribution in the catches.

Echo-survey abundance index was used to tune the models. The echo-surveys were carried out for both the western and eastern sides from 2004 onwards. Western echo-survey abundances were split into age classes by the means of length frequency distribution and ALK coming from the western echo-survey. On the other hand, eastern echo-survey biomass was distributed into age classes by the means of proportion at length from the 2009 eastern echosurvey and age-length keys from the Croatian commercial fleet.

The 2011 eastern echo-survey covered only about 50% of the total area: for this reason, an average percentage of the biomass in that area from the previous years (2004-2010) was applied.

Also, this year for tuning the assessment we used an index of biomass for anchovy from 2000 to 2011 coming from bottom trawl survey (MEDITS). Since trawl survey target demersal species, weight for this tuning index was lower (0.3) than the one for echo-survey (1.0).

Split year was used, by fixing the birthday date on the first of June, according to the biology of this species in the Adriatic Sea.

The natural mortality rate M was taken as variable over age and was calculated using the Gislason's equation. The growth parameters required by this method were derived from Sinovcic et al (2000).

Assessment method

Integrated Catch Analysis (ICA) and Virtual Population Analysis (VPA) with Laurec-Shepherd tuning.

Model performance

The ICA model performed well with the data available: the marginal totals of residuals between the catch and the separable model are overall small, as well as reasonably trend-free in the separable period (2000-2011). The CVs are on the overall lower than 20%. The retrospective pattern is low, except for some degree in the F estimates in 2010.

The VPA model gave similar results in terms of biomass, but the standard error for the q estimates are a little bit higher than the suggested 0.5. The restrospective pattern is much higher than in the ICA.

Results

The trend in biomass of anchovy obtained by both ICA and VPA increases up to a maximum in 2005, then decrease until 2009, and then increase again the the last two years. The 2011 VPA spawning stock biomass estimate is equal to 309361 tons, while the estimate is slightly lower in the ICA (SSB = 264565 tons). The current biomass is above the proposed reference points B_{lim} and B_{pa}.

The ICA fishing mortality decreases constantly until 2007 and then increases again, being higher for age 2 and 3. The $F_{bar(1-3)}$ in 2011 is equal to 0.61.

The recent exploitation rate $F/Z_{(1-3)}$ is right on the Patterson's threshold 0.4, after a couple of years in which it was above it. The catch ratio is back to the lowest values registered since the beginning of the time series, which is around a value of 0.1.

Diagnose of Stock status

At the present the stock can be considered as sustainably exploited, being the fishing mortality ($E_{(1-3)}$ = 0.41) equal to the RP (E = 0.4); the level of abundance is considered intermediate (current biomass = 333404 tons) higher than the proposed B_{lim} (179000 tons) and B_{pa} (250600 tons) reference points.

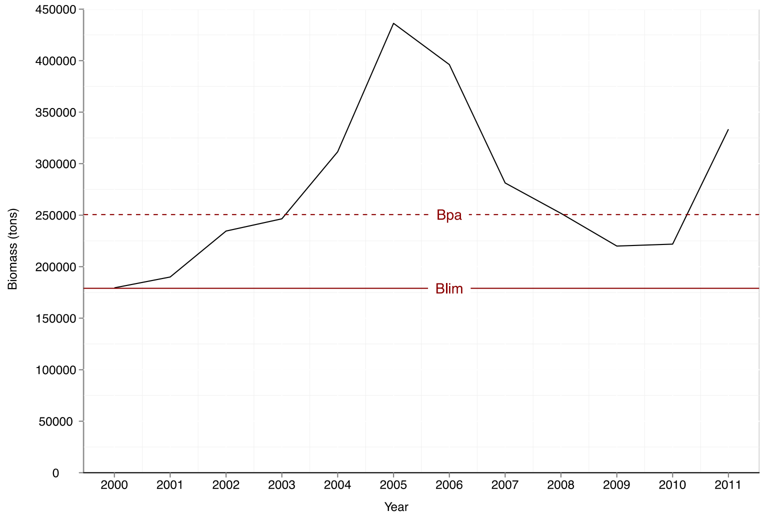

Fig. GSA_17_anc.1: Mid-year stock biomass and proposed reference points.

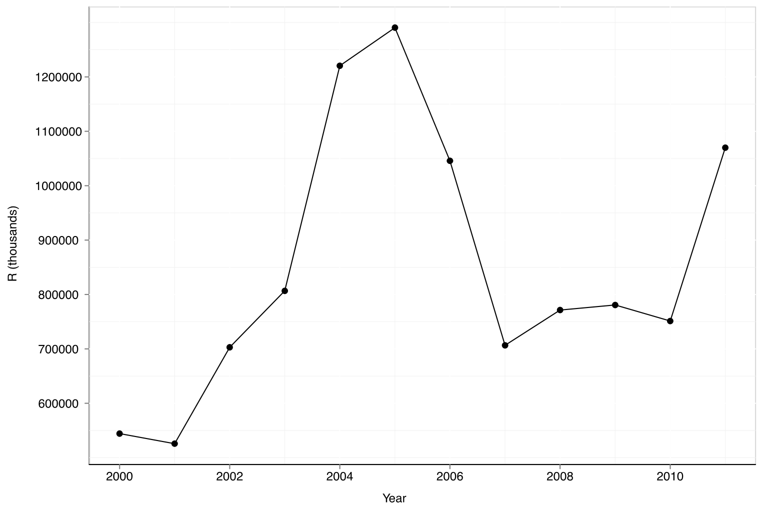

Fig. GSA_17_anc.2: Recruitment estimates (in thousands).

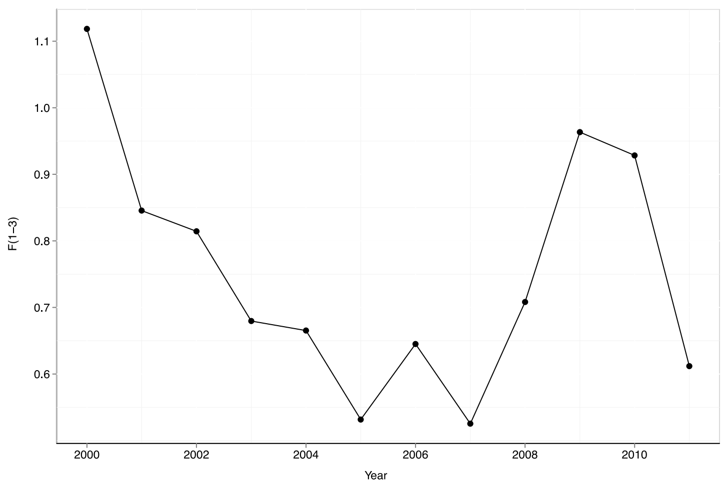

Fig. GSA_17_anc.3: Fbar(1-3) estimates.

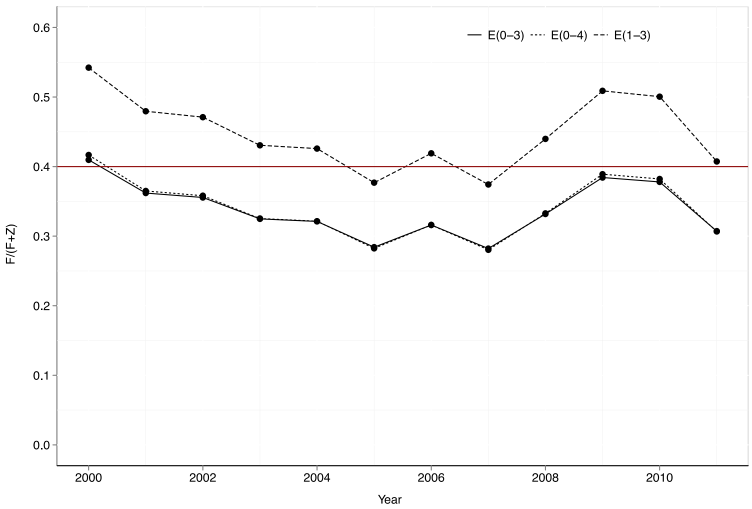

Fig. GSA_17_anc.4: Exploitation rate (F/Z).

Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
[2000-2011]		[2000-2011]	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
X	Sustainable Fishing Mortality	**X**	Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
[2000-2011]		[2000-2011]	
[179452 tons – 436249 tons]		[52578000 - 129050000 thousands]	
X	Stable	**X**	Stable
	Increasing		Increasing
	Decreasing		Decreasing

Advices and recommendations

Since this stock can display large fluctuations associated with analogous fluctuations in recruitment, and since the exploitation rate is on our precautionary threshold of 0.4, the advice is not to increase the fishing effort. Nevertheless, since numerous studies have shown that the dynamics of anchovy and sardine populations are strongly influenced by success in the recruitment that is, on the other hand, strongly influenced by environmental conditions, the working group suggests continuing to explore the relationships between these species and the environment.

WG recognised that spatial distribution of shared stock of anchovy is not limited to GSA17 area only, but it is extended in GSA18 area also. Therefore, WG suggest that future assessments try to take into account combined data from these two GSAs.

Discussion

It should be noted that Adriatic small pelagic fishery is multispecies and effort on sardine stock cannot be separated from effort on stock of anchovy. Hence, management decisions have to be taken considering both species.

The approach used in this assessment was to maintain the independence of the dataset during the preparation of the input data in order to reduce the statistical dependence (Cotter et al., 2004): the working group tried, whenever possible, to treat echo-survey data as more independent as possible from the commercial data.

Since it's the first time that biomass reference points are proposed for this stock, and since they were proposed based on the time series assessed, they should be revised in three years, when new data will be available.

GSA 18 – Southern Adriatic Sea

Anchovy (*Engraulis encrasicolus*)

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Fishery

1. *Italy*

Anchovy is exploited by pelagic trawl, purse seine and to a lower level by bottom trawl (bycatch of small pelagics). Highest landings in weight are those of pelagic trawling followed by purse seine. Fishing is carried out five days a week. Exploitation is mainly based on age classes 1 and 2. Purse seiners during most of the fishing season operate in GSA 17. Pelagic trawlers mainly fishing small individuals (bianchetto) are no more allowed to operate.

From official data, the pelagic trawl and purse seine fleet of the geographical sub-area 18 (South-Western Adriatic Sea) is made up by 41 boats, but not all of them are operating all over the year.

2. *Montenegro*

In Montenegro commercial catch of small pelagic species at the open sea is undeveloped, catches are concentrated mostly on Boka Kotorska Bay, so it isn't possible to estimate biomass or MSY from commercial landings data.

At present time, there are only two active vessels (purse seiners) that are exploiting these resources in Montenegro but the catches are poor, probably because of lack of experience of the crew and some technical problems. Even when catches are accomplished there is a big problem in its sale because of unorganized market.

So, anchovy is targeted mostly by small scale fisheries, small purse seine and beach seine (LOA 6-8 meters). Fishing grounds are located along the coast, and also in the Boka Kotorska Bay. In small scale fishery almost all types of nets are used (gillnet, purse seines, beach seines, trammel net etc. and long lines). With this type of fishery, a lot of economically important fishes are caught but there are no precise data about their amounts.

3. *Albania*

There are 7 pelagic vessels in Albania, which are active for 3 - 5 months during the year. Half of the catch is exported and the rest is used by the conservation industry.

Data and parameters

Data concerning Italian official commercial landings come from IREPA.

Anchovy biomass was assessed by two direct methods, acoustics and DEPM, in the frameworks of MEDIAS and AdriaMed project in both sides of GSA 18. Survey period was July – August 2011.

Reproductive parameters of adult population were processed directly onboard (total length, weight with and without gonads, sex ratio and maturity stages), while batch fecundity (F) and spawning frequencies (S) were analysed in the laboratory. Plankton samples were processed in the laboratory using methodology given by Regner (1985). Developmental time from fertilization to hatching (D) was analyzed and also instantaneous mortality rates of eggs, average and total daily egg production. During 2012 DEPM methodology previously used in Adriatic for anchovy SSB estimation was revised. Revised methodology was used for the preliminary estimation of anchovy SSB in GSA 18 in 2011.

Assessment method

- DEPM

Results

Results on preliminary estimation of anchovy SSB are presented in tables separately for the eastern and western part. Those results are not final and will be under further processing.

	Western GSA 18	Eastern GSA 18
Total surveyed area (km^2)	13487	13113
Daily egg production (N eggs/m^2 * day^{-1})	57.23	38.93
Average weight of mature females (g)	9.39	10.87
Sex ratio	0.549	0.425
Mortality	0.15	0.58
Spawning frequency (POF)	0.17	0.17
Batch fecundity	6328.04	632.04
SSB (tonnes)	12262.34	12139.38

Diagnose of Stock status

Since this is just a preliminary estimation it is not possible to diagnose the status of the anchovy stock in GSA 18 based on the DEPM investigation.

Advice and recommendation

Eastern GSA 18: Due to the lack of consistent informations on landings it is possible to say only that the stock could not be overexploited because in any case it is well known that fishing pressure here is low expecially in Montenegro. In any case if an increase in fishing effort is foreseen in eastern GSA 18 for a precautionary approach it has to be introduced slowly and step by step, due to the fact that this stock is shared in the GSA 18 between 3 countries and fishing effort from the Italian fleet is higher.

Western GSA 18: anchovy is targeted mainly by purse seiners and pelagic trawls; fishing effort is bigger than in the eastern side; in any case it is known that part of the fleet operates in GSA 17. On the base of this information it is possible to say only that it is unlikely that anchovy stock is overexploited here.

Continue with the two direct assessments of anchovy biomass of all GSA 18, estimating also the exploitation rate in the best way that is possible. Try to improve the quality and availability of landings data. Revision of the previous anchovy SSB estimation will be made (2008 and 2010).

GSA 29 – Black Sea

Sprat (*Sprattus sprattus*)

Author(s): V. St. Raykov

Fishery

The Black Sea sprat (*Sprattus sprattus L.*) is a key species in the Black Sea ecosystem. Sprat is a marine pelagic schooling species, sometimes entering in the estuaries (especially as juveniles) and the Azov Sea and tolerating salinities as low as 4‰. Sprat is one of the most important fish species, being fished and consumed traditionally in the Black Sea countries. It is most abundant small pelagic fish species in the region, together with anchovy and horse mackerel and accounts for most of the landings in the north-western part of the Black Sea. Whiting is also taken as a by-catch in the sprat fishery, although there is no targeted fishery beyond this (Raykov, 2006) except for Turkish waters. Sprat fishing takes place on the continental shelf on 15-110 m of depth (Shlyakhov, Shlyakhova, 2011).

The harvesting of the Black Sea sprat is conducted during the day time when its aggregations become denser and are successfully fished with trawls. The main fishing gears are mid-water otter trawl, pelagic pair trawls and uncovered pound nets. The species is fast growing; age comprises 4-5 age groups. Sprat has lengths comprised between 50 and 120 mm, the highest frequency pertaining to the individuals of 70-100 mm lengths. The age corresponding to these lengths was 0+ - 4-4+, the ages 2-2+ - 3-3+ having a significant participation. By 1982, the age classes 4-4+ years had a share of 34% from the catch of this species, then the percentage continually decreased up to 1995 when this age was not signalled, meaning the increase of the pressure through fishing exerted on the populations. While the share of this age decreased, the prevalence of 0+ especially 1-1+ ages became increased. During last years the age structure show the presence of the specimens of $1\text{-}1^{+}$ and 3; 3^{+} years, the catch base being the individuals of $1\text{-}1^{+}$ and $2\text{-}2^{+}$ years. The sprat fishery is taking place in the Black Sea (GFCM Fishing Sub-area 37.4 (Division 37.4.2) and Geographical Sub-area (GSA) 29).

The opportunities of marine fishing are limited by the specific characteristics of the Black Sea. The exploitation of the fish recourses is limited in the shelf area. The water below 100-150 m is anoxic and contains hydrogen sulphide. In Bulgarian, Romanian, Russian and Ukrainian waters the most intensive fisheries of Black Sea sprat is conducted in April till October with mid-water trawls on vessels 15- 40 m long and a small number vessels >40m. Beyond the 12-mile zone a special permission is needed for fishing. Harvesting of Black Sea sprat is conducted during the day, when the sprat aggregations become denser and are successfully fished with mid-water trawls.

The significance of the sprat fishery in Turkey in the last three years has increased and the landings reached 57 023 t in 2010. The main gears used for sprat fishery in Turkey (fishing area is constrained in front of the city of Samsun) are pelagic pair trawls working in spring at 20-40m depth and in autumn - in deeper water: 40-80m depths.

Data and parameters

The information used for the assessment of the stock consisted of annual catch and landings of 6 Black Sea countries official landings and biological parameters estimated from data collected in the GSA29 (1991-2010).The most recent (for Bulgaria and Romania) data were collected under the DCR (EC 199/2008). Commercial catch in Bulgaria was composed from 1-1+ and 2-2+ old specimen, mainly. Similar trends were observed in scientific surveys.

Samples collected from Turkish pelagic trawls operating in shallow waters (40-60 m) also confirm the tendency that larger/older fish (Age 3 and 4) is distributed mostly in deeper waters DCF nominal fishing effort (kw*days at sea and number of vessels) as submitted to JRC through the DCF 2011 Med and Black Sea data call by major gear type, 2008-2010 were analyzed.

CPUE series were derived from scientific surveys of Bulgaria and Ukraine and tuning series were created and used in further ICA analysis. Trends in abundance by age from surveys in Romania and Bulgaria were analyzed as well. Age composition of commercial and survey catches of sprat show lower selectivity of larger/older fish by the Bulgarian commercial fleet and in shallower waters. Length has bimodal distribution in terms of (85-90mm) and (90-95mm). Sub dominated are the ranges 80-85 and 95-100mm.Catch-at-age matrix was created using data from BS countries. Natural mortality used equals to 0.95.Weith-at-catch (kg) in the stock and in the catches (kg).

Assessment method

Integrated Catch-at-age Analysis (ICA; Patterson and Melvin, 1996). ICA combines the power and accuracy of a statistical model with the flexibility of setting different options of the parameters (e.g. a separable model accounting for age effects) and for this raison is suitable for a short living species (age 5 at maximum) such as the Black Sea sprat.

Model performance

The results of the ICA show a reasonable agreement with tuning data

Results

E (mean)	≤ 0.4

Table of limit and precautionary management reference points agreed by fisheries managers

F_{msy} (age range)=	none
B_{pa} (B_{lim}, spawning stock)=	none

Over the last few years the fishing mortality has piqued in 2005 and 2009 at a level of about F=0.59. This equals an exploitation rate of about E=0.38 (natural mortality M= 0.95). Proposing a limit reference point of exploitation rate E≤0.4, the WG considers the stock of sprat in the Black Sea as sustainably exploited. Status quo fishing implies catches in the range of 90 000 to 100 000 t over 2011 - 2013.

Diagnosis of stock status

The SSB ranges at medium to high levels: in the range of 300 - 400 000 t. Under a constant recruitment scenario and status quo F, SSB is expected to stay at the approximate same level by 2013

After a positive trend in 1999-2001 the recruitment has decreased in 2002-2004 and increased again since 2006. Recruitment estimates in 2008 and 2009 are rather imprecise due to the lack of survey data. In short-term forecast we used a geometric mean over 2008-2010 average value of 172 832 224 000.

Advices and recommendation

- The stock was being sustainably exploited close to the biological reference point of E≤0.4 consistent with high long term yields. EWG 11-16, Daskalov et al., 2011 recommends a sustainable status quo exploitation for 2012 which implies catches of 100 000 t not to be exceeded in 2012. In the absence of an allocation key for the international sprat catches, EWG 11-16 is unable to advice on a specific EU TAC for sprat in the Black Sea.
- A short term prediction of stock size and catches assuming a sustainable status quo fishing scenario has been provided together with a range of management options. Considering the short life span of sprat in the Black Sea and the high variation in estimated recruitment, EWG 11-16 emphasises that the short term projections based on geometric mean recruitment and the resulting catch advice are subject to high uncertainty. The poor knowledge about the recruitment dynamics prevented the formulation of medium term projections.

GSA 29 – Black Sea

Horse mackerel (*Trachurus mediterraneus ponticus*)

Author(s): M. Yankova

The Black sea horse mackerel is a subspecies of the Mediterranean horse mackerel *Trachurus mediterraneus.* Although in the past the Black sea horse mackerel has been attributed to various subpopulations, in a more recent study Prodanov *et al.* (1997) brought evidence that the horse mackerel rather exists as a single population in the Black sea, and thus all Black sea horse mackerel fished across the region should be treated as a unit stock.

The horse mackerel is a migratory species distributed in the whole Black Sea (Ivanov and Beverton, 1985). In the spring it migrates to the north for reproduction and feeding. In summer the horse mackerel is distributed preferably in the shelf waters above the seasonal thermocline. In the autumn it migrates towards the withering grounds along the Anatolian and Caucasian coasts migration (Ivanov and Beverton, 1985). The horse mackerel population in the Black Sea mainly winters along the Crimean, Caucasian and Anatolian coasts and warm sections of the Marmara Sea. The horse mackerel (*Trachurus mediterraneus*) fishery operates mainly on the wintering grounds in the southern Black Sea using purse seine and mid-water trawls.

The catches of Black sea horse mackerel were realized by active (bathypelagic trawls and surrounding nets) and passive fishing gears (gill netting, trawl net, trap nets) (Prodanov *et al.,* 1997; Yankova *et al.,* 2010a). The Bulgarian and Romanian catches are taken primarily by passive, while the Turkish and former USSR entities by active gears (Prodanov *et al.,* 1997). The horse mackerel of age 1-3 years generally prevails in the commercial catches (Grishin *et al.,* 2007; Yankova and Raykov, 2009; Yankova *et al.,* 2010a), but strong year classes (for example, the 1969 year class) may enter into exploitation at age of 0.5 year and may prevail up to age 5-6 years (Grishin et al., 2007). The accuracy of the stock assessments depends exclusively on the fishery statistical data (Prodanov *et al.,* 1997). There are lack of information on horse mackerel catches or its underestimation by Russia, Ukraine and Georgia, Romania and Bulgaria enhances the risk of an incorrect assessment of biomasses. Over the last 40 years, highest horse mackerel catches were reported in the years preceding *Mnemiopsis leidyi* outbreak (1988-1990) (Prodanov *et al.,* 1997). The improvements of fishing gears and the application of modern echo-acoustics further contribute to a more effective fishery (Prodanov *et al.,* 1997). The same authors reported that when the level of the horse mackerel stock was low, even small catches caused higher fishing mortality, and vice versa. All this stresses the necessity of annual assessments of stock size, of TAC`s, as well as of clarifying the causes (natural and anthropogenic) determining fluctuations in year class strength.

The ratios of undersized individuals for horse mackerel were 89% and 92% for autumn and winter seasons, respectively. The corresponding ratios for the horse mackerel for the same seasons were 70 and 67%, respectively. The length of the horse mackerel population off the southern Black Sea coast after they reach initial reproductive maturity is 11.7 cm (Genç *et al*., 1999).

Horse mackerel stocks in the Black Sea are usually caught by Turkish fishermen by using active (bottom trawler, pelagic trawler and large bag-shaped nets) and passive (extension and longline) nets. Almost the whole horse mackerel catch (98.2%) is caught by large bag-shaped nets. CPUE of fishing boats using that type of net for catching horse mackerel is 3837.5 (600-10,000) kg/boat/day (Zengin *et al*., 2003). The remaining part of the catch is caught by bottom trawler, pelagic trawler, extension net and long lines. A large part of the catch (80%) is caught in the autumn and the first part of winter (September-December) (Zengin *et al.,* 1998a).

Data and parameters

For the period of the study (2004-2010), the methodology applied was a 3 versions of separable VPAs with terminal fishing mortalities F=0.4, F=0.8 and F=1.2. This range has been chosen after a review of the results obtained from the Jones method (Ukrainian waters). The software used was FLR. The weight at age in the catch by age was calculated for all Black Sea countries. Total catch of species and aggregated catch at age in in number 10^{-3} of Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine was applied.

Model performance

The preliminary analysis for stock assessment did not show any clear trend.

Results

The analysis is a trend indicative only. The lack of a fishery independent scientific survey to monitor horse mackerel all over the Black Sea to indicate trends in total mortality and recruitment appears the major data deficiency in the assessment.

Diagnosis of stock status:

The stock is characterized by higher recruitment (2010), which ensures the sustainability of the stock at a low level of abundance. All three assessments formulations indicate that the SSB in 2010 is reduced from a higher level. In the absence of total stock size estimates and biological reference points, it is not possible to fully evaluate the stock size with regard to the precautionary approach.

Advices and recommendations

Data from the Turkish fisheries will be very important but horse mackerel fisheries are quite important for all Black Sea countries. Biological (age and individual size and growth) and survey data (acoustics, juveniles, and egg-production) from all countries need to be thoroughly compiled.

1) Joint scientific research expeditions should take place.
2) A regional coordination and standardization of the methods of sampling, processing, analysing and interpreting of data (age reading) regulations are needed.
3) Development of an informational system including fisheries data (markedly CPUE) for Black Sea countries is needed.

GENERAL DISCUSSION

Discussion on reference point

26. The estimation of reference points for small pelagic has been one of the main issues discussed during this year working group. Generic reference as the one provided by Patterson have been used by the group for fishing mortality, but no reference point for biomass have been previously used by the Group.

27. The definition of reference points for small pelagics has always been hard due to the high variability and the high fluctuations of the recruitment (fig 1). These fluctuations are driven by a combination of environmental variables and fishery activities, and it's hard to forecast the magnitude and the trend in the fluctuations. The environmental variables affecting those stocks are several and not well known and defined.

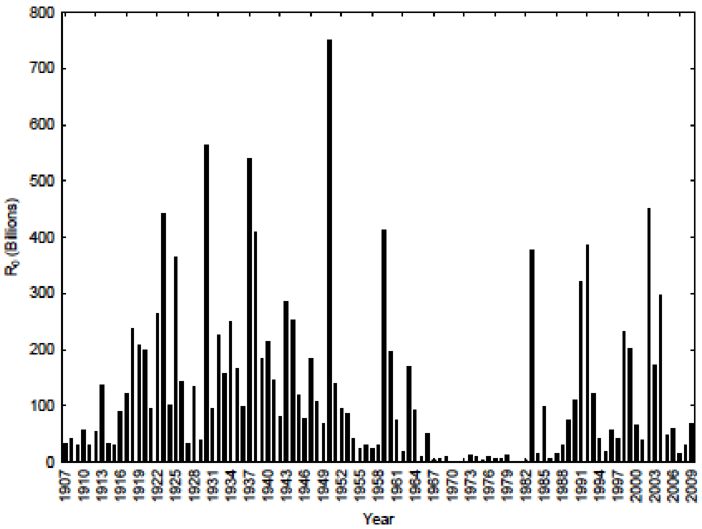


Fig. 1 Historic fluctuations of herring recruitment in northern seas (A. Slotte; WGSPEC 2012)

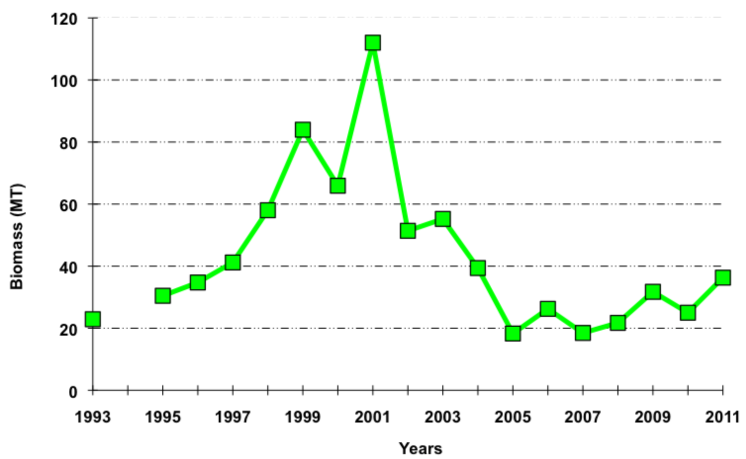
28. The working group decided to base the estimation of reference points for biomass on the trend in biomass observed for the assessed stock. The lowest value in the more recent year is taken as a limit biomass below which recruitment is impaired or there is a high risk that the stock is not able to regenerate, and therefore the fishery has to be closed. B_{pa} has been established in relation to B_{lim} assuming B_{pa} = 1.4 B_{lim} (B_{pa} 40% higher than B_{lim}). The group will like this relation to be further investigated in future years, and base the relation between B_{pa} and B_{lim} in an estimated or assumed coefficient of variance of the biomass estimator.

29. The working group discussed about the advantages and disadvantages of defining a reference point based on estimated trends.

    I. Advantages:
    - It's objective.
    - With enough data to see cycles can be a good indicator for management regulations.
    - It takes into account fluctuations.
    - It's empirical, which means it's something that it can be observed.

II. Disadvantages:
- It can changes every year, whenever new information enters the time series.
- It's not known at which level of the cycle the stock is (peak or depression in the stock biomass), unless decades are available.
- Subjectivity in the definition of the length of the time series: which is the minimum number of years needed to define a RP?
- If no cycles are evident in the time series, the safeness of the reference point can be questioned.

30. The group also discussed if reference points for management actions on small pelagic stocks should be dependent on the phase (level of biomass) in which the stock is (i.e. whether the stock is on a low biomass or high biomass phase). (see figure 2 below). This approach is also common in other areas of the world in which large small pelagic fisheries are in place.



31. Also the possibility of using direct methods alone to define RPs was discussed in the group. The main problem in the use of direct methods is that the time series available are usually short, but also the difficulties on having an absolute estimate have been pointed out in the discussion.

32. It was possible to provide a B_{lim} and a B_{pa} reference points for the stock of anchovy and sardine in GSA 17 since the fluctuations in the recruitment are low compared to other small pelagic stocks around the world; besides, the lowest point in the assessed time series corresponds roughly to the lowest point in the historical time series which covers 36 years of data.

33. The WG agreed that a regular revision of the reference points should be established. On one hand the Group recommends the RP to stay stable for some years unless a severe criticism arise, in order to avoid incorporating too much uncertainty from the assessment models itself and to correspond to pluri-annual management plan. But also the WG recommend the reference points to be revised on dedicated meetings, or on regular meetings in which the revision of the reference points is incorporated in the terms of reference. As a balance the WG recommends to revise the proposed reference points every 3 years.

Assessment models to-do-list and potential alternative assessment models

34. As in previous years, the problem of using only age or length-based model in short living species with a variable growth was raised. Two applications of biomass models were presented during this WG (BioDyn and Shaefer model) and the WG encourages, whenever possible, some comparative analysis between the performance of existing biomass models and analytical models.

35. This year Morocco performed a length cohorts analysis: the WG thinks that the data available are enough to attempt a more complex model, such as an age based model.

Long-term management of small pelagic fish stocks

36. The need to establish some indicators of environmental stress was highlighted and a recommendation to progress in this direction is done, also in coherence with the proposed use of a "traffic light approach" recommended by SAC. The first attempts to use primary productivity (Chl. A) in the Southern Sicily were commented. The convenience of getting information on oceanographic parameters while doing the surveys was also highlighted as well as providing results of studies on biological and oceanographic factors performed within other running projects.

DISCUSSION ON STOCK ASSESSMENT FORMS AND INDIVIDUAL REPORT TEMPLATES

37. The participants provided their suggestions to improve the structure, the contents and the utility of the new Stock Assessment Forms proposed for this year.

38. During the last years, the working groups have evolved from "hands on" sessions in which the participants provided data to run the assessments, towards a revision type sessions in which the assessments are previously done and the WG discuss the assumptions taken and the results found. In sub regional *Ad hoc* working groups or in their own Institutes the scientists meet together and elaborate their assessments which results are finally addressed to the SCSA Working Groups. Hence, the objectives, of the working groups and consequently those of the stock assessment forms must be adapted to this evolution.

39. Under the new working procedures, the assessment forms must make sure that the participants can:

   - Have more flexibility in including as much information as possible.
   - Evaluate the assumptions taken as well as the preliminary analysis that allows making those assumptions.
   - Evaluate the results obtained in the assessment and therefore discuss on the conclusions and recommendations proposed.

40. The WG agreed with the conversion of the stock assessment form into a word document.

41. The main discussion concerned the formulation of the advices and the last section with the

summary tables. The members discussed about the contradictions between the unidimensional and bidimensional table and the final agreement was to fill up only one of the two.

42. The WG adopted some changes in the bidimensional table:

- Separation of the definition of 'virgin stock' from the definition of 'high abundance'.
- Separation of the definition of 'no fishing mortality' to the definition 'low fishing mortality'.
- Replacement of 'moderate fishing mortality' with 'sustainable fishing mortality'.

43. The WG added a table about trends in biomass and recruitment. Even though the analysis of trends does not assess directly the state of the resources, it gives an idea of the likely state in which the stock might be, considering its empirical historical development.

44. The WG proposed to insert figures about the main results (e.g. spawning stock biomass, recruitment and F) in the scientific advice section, below the tables.

45. The section about direct methods, historical trends, input data and results should include standard ways of presenting the data and outcomes, independently of the method used (e.g. abundance by age bubble plots from catches and surveys to evaluate cohort signals, estimates of abundance by age by year by the model, plots of F, SSB and Recruitment, etc.). Some automatic routines will also be desirable.

46. In addition to the stock assessment forms, it is also suggested that some clarifications on the use of the individual report template provided to the participants and used to compile the information required for the final report are needed:

- Under the section on "Model performance", participants should include an own critical evaluation of the model used, including an evaluation of the model diagnostic plots provided by most analytical assessment (e.g. residual plots by age, survey, etc.) as well as (when available) an evaluation of agreement between direct estimates and catches (e.g. showing the catchability and selectivity of surveys) and a critical evaluation on the suitability of the assumptions taken.
- Under the section on "Discussion", the discussion taken place on the WG should be included, as well as whether or not the WG arrived to an agreement on the conclusions and recommendations for that stock.

GENERAL RECOMMENDATIONS

- The WG recommends continuing current efforts to provide combined analysis for stocks that span through more than one GSA area, as well as coordination between Institutes and nations involved in the assessment of shared pelagic fish stocks. In particular:
    - To continue the effort of standardizing the acoustic survey among the countries in the Alboran Sea (namely Alger, Spain and Morocco) and of joining the data in order to perform a common stock assessment of small pelagic in the area.
    - To perform a joint assessment between anchovy and sardine stock in GSA 17 and GSA 18.

- The WG recommends to improve the separation between recruits and adults in the Gulf of Lions.
- The WG recommends to adopt the biomass reference points proposed in the previous sections for the Southern Sicily and the Northern Adriatic Sea.
- The WG encourages to have all the data (catches and survey data) available on time (at least 3 months before), whenever possible.
- For the Black Sea the WG recommends:
  - To have a common acoustic survey for the whole area.
  - To have eggs and juveniles for anchovy and horse mackerel in the north-eastern part.
  - Each GFCM members should provide horse mackerel data on catch per unit effort and other needed variables (e.g. biological) at least a month before the assessment WG.
  - To have a combined direct survey for anchovy and horse mackerel in the north,
  - To extent the database to non-GFCM members in order to have complete information on the Black Sea species (sprat, anchovy and horse mackerel).
- The WG recommends to keep the new assessment forms and amend several issues:
  - New tables in the 'Scientific advice' section.
  - Since the WG will keep on improving RPs estimations, the effort will be toward the definition of a table explicitly for reference points.
- The WG agreed in having an internal chairman to be reelected for a period of three years.
- The WG recommends that a specific workshop on assessment methods for small pelagic fish is carried out. Potential issues to be covered by the workshop include i) the use of aggregated or disaggregated (recruitment and spawning stock) Biomass models to evaluate small pelagic fish stocks, ii) Bayesian techniques to incorporate assumptions, prior distribution of the unknown parameters and/or external information such as environmental indexes and tuning indexes, iii) analysis of time series to identify changes in the ecosystem and iv) management options for variable carrying capacity small pelagic fish stocks.
- The WG recommends attempting joint activities between the Black sea and the Mediterranean scientists.
- The WG recommends all the members to upload a draft of the stock assessment form few days before the following working group. Besides, it is required to have the title of the presentations at least a month before it, to allow the organizers to define the agenda and the duration of the meeting based on the number of participants.
- The WG recommends to keep the online system and to allow a yearly license for the participants. It also strongly recommends to use the online system to share scripts and software among the members of the WG.
- The WG recommends that the report should be public and available online.
- The WG strongly recommends to always have a backstopping officer from the secretariat.
- The WG encourages holding the next meeting in Spain.
- In relation to last year recommendations:
  - For short-term management, the WG recommends to perform risk analysis of stock projections using different probabilistic scenarios based on possible levels of recruitment. The evaluation of the use of stock recruitment relationship, if necessary with some extra environmental index, is also recommended, due to the good correlations observed in some of the stocks.
  - For long-term management, the WG recommends to undertake a basin-wide

analysis to identify climate signals that can be coherent at the Mediterranean Sea spatial level, in order to identify potential phases or regime shifts that can control stock productivity. An analysis of basin-wide signals versus local effects on recruitment is encouraged.

- The WG also recommends investigating the possibility to incorporate some indication of environmental stress on the stock productivity into the traffic light approach recommended by SAC. The convenience of getting information on oceanographic parameters while doing the surveys was also highlighted as well as providing results of studies on biological and oceanographic factors performed within other running projects.

ADOPTION OF THE REPORT AND OF THE RECOMMENDATIONS FROM THE GROUP

47. The Conclusions and Recommendations were adopted by the Working Group on 9th of November 2012. The whole report was adopted after revisions and amendments by electronic correspondence within the next two weeks.

Reference:

Genç, Y., Zengin, M., Başar, S., Tabak, I., Ceylan, N., Çiftci, Y., Ustϋndağ, C., Akbulut, B. & Şahin, T. 1999. The Research Project of Economical Marine Products. TKB, Central Fisheries Research Institute Trabzon, 157 pp.

Grishin, A., Daskalov, G., Shlyakhov, V. & Mihneva, V. 2007. Influence of gelatinous zooplankton on fish stocks in the Black Sea: analysis of biological time-series. Marine Ecological Journal, 6(2), Sevastopol, 5-24.

Ivanov, L.S. & Beverton, R.J.H. 1985. The fisheries resourses of the Miterranean. Part two: Black Sea. Etud. Rev. CGPM/ Studies and Reviews, CFCM 60: 135 pp.

Prodanov, K., Mikhailov, K., Daskalov, G., Maxim, K., Chashchin, A., Arkhipov, A., Shlyakhov, V. & Ozdamar, E. 1997. General fisheries council for Mediterranean, FAO. Studied and reviews № 68, pp. 73-81.

Slotte, A. 2012. Impact of climate variability on herring and capelin in northern seas. In: ICES, Report of the Working Group on Small Pelagic Fishes, their Ecosystems and Climate Impact (WGSPEC), 27 February – 2 March 2012, Fuengirola, Spain. ICES CM 2012/SSGEF:10. Pp 41-45.

Yankova, M. & Raykov, V. 2009. Resent investigation on population structure of Horse mackerel (*Trachurus mediterraneus ponticus* Aleev., 1956) in the Bulgarian Black Sea coast. Proceedings of the Institute of Fishing Resources Varna, Volume 27, 39-46.

Yankova, M., Raykov, V., Gerdzhikov, D. & Bogomilova, P. 2010a. Growth and Length-Weight Relationships of the Horse Mackerel, *Trachurus mediterraneus ponticus* (Aleev, 1956) in the Bulgarian Black Sea Coast. Turkish Journal of Zoology, Volume 34, Issue 1, 85-92.

Zengin, M., Duzgunes, E. & Okumus, I. 1998. Evaluation of data from market samples on the commercial fish species in the Black Sea during 1990-1995. In: Celikkale, M. S. et al., (Eds). The Proceeding of the First International Symposium on Fisheries and Ecology. Trabzon, pp. 91-99.

Zengin, M. 2003. The Current Status of Turkey's Black Sea Fisheries and Suggestions on the Use of Those Fisheries, Workshop on Responsible Fisheries in the Black Sea and the Azov Sea, and Case of Demersal Fish Resources, April 15-17 2003, Şile, Istanbul, BSEP Black Sea Environmental Programme Country Report, 34 pp.

Appendix A

AGENDA

1. **Opening session (joint session for the two Working Groups on Demersal and Small Pelagic Species)**
   - Opening, arrangement of the meetings
   - Logistical aspects
   - Presentation of the new Stock Assessment forms
   - Structure of the report

2. **Introductory session**
   - Adoption of the Agenda
   - Nomination of WG Coordinator and rapporteur(s)
   - Review of last year conclusions and recommendations

3. **Preliminary assessments and assessment related information** (presentations by national experts, about 15 min each, followed by 15 minutes of discussion)
   - Omar Kada: joint assessment of sardine in Alborán
   - Omar Kada: Acoustic survey in Morocco

4. **Presentation and discussion of draft assessments** (presentations by national experts, about 15 min per stock, followed by 15 minutes of discussion)
   - Piera Carpi: Stock assessment of anchovy and sardine in GSA 17
   - Ana Pesic: Preliminary results of anchovy SSB in the South Adriatic Sea (GSA 18)
   - Claire Saraux ; Gulf of Lions sardine and anchovy distribution
   - Bigot Jean Louis : Stock assessment of gulf of lions sardine and anchovy
   - Bernardo Patti: Stock assessment forms for *Sardina pilchardus* in GSA16

5. **Practical session to finalize individual reports and SAFs.**

   (*Cont'*) Presentation and discussion of draft assessments
   - Bernardo Patti: Stock assessment forms for *Engraulis encrasicolus* in GSA16

6. **Discussion on reference points:**
   - Use of generic reference points
   - Reference points for biomass and F
   - Review of the reference points used in this WG

   (Cont') Preliminary assessments and assessment related information
   - Juan A. Camiñas: Advances in preparing a joint assessment on *E. encrasicholus* of the Alboran area.

7. **Discussion on how to provide advice on the status of the stock**

8. **Presentation and discussion of draft assessments**
   - Violin Raykov: Fisheries, stock assessments and gaps in knowledge of Sprat (*Sprattus sprattus* L) of Bulgarian Black Sea area.
   - Maria Yankova: Stock assessment of Black Sea horse mackerel

9. **Joint discussion between small pelagics and demersal working groups about advices and reference points**

10. **Presentation and discussion of draft assessments** (presentations by national experts, about 15 min per stock, followed by 15 minutes of discussion)
    - Bernardo Patti: presentation about Bmsy
    - Samia Ben Smail: Sardine stock in Algeria

11. **Review of the advices for the stocks assessed this year**

12. **Conclusions on the Stock Assessment Form**

13. **Future organization of the Working group**

14. **Formulation of conclusions, recommendations and management advices to be transmitted for the consideration by the SCSA and SAC** (Preparation of draft report)

15. **Closing Session:**

- Date and venue of the next meeting
- Any other matter
- Adoption of the draft Report

Appendix B

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Appendix C

GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

COMMISSION GÉNÉRALE DES PÊCHES POUR LA MÉDITERRANÉE

Draft Terms of Reference for the SCSA Working Groups on Stock Assessment for demersal and small pelagic species.

One of the objectives of the Sub-Committee on Stock Assessment (SCSA) is to progress in the enhancement of joint practical stock assessment. "Joint" refers to the participation of scientists from different countries providing their data and sharing them with their colleagues, using a standard method and analyzing together the results and options for fisheries management.

The main objective of the annual meetings of the two Working Groups is to give advice on those stocks that are well assessed, "well" meaning agreed by the group on the type of data, on the parameters used and on the methodology applied. Specifically, the group will, on a stock by stock basis:

1. Analyse the data sets provided by the participants (Sampling frequency, time series, age structured, commercial vs surveys data, …)
2. Check parameters used and methodology applied on the assessments already done "at home".
3. Resume the performance of the methods through sensitivity tests and residuals analysis.
4. Run stock assessments on the cases not previously done with the data sets available and with the agreed methodology on a practical session.
5. Get the actual values of the biological reference points (BRP) and compare with those agreed at the 13th SAC meeting, namely FMSY or its proxy $F_{0.1}$ as the Target Reference Point and F_{max} as provisional Limit Reference Point.
6. In cases where BRP cannot be obtained use an empirical approach based on standing stock as stock status indicator, the harvest ratio (catch/biomass from survey) as fishing impact, and some indicators (SST, Chlorophyll, condition factor,…) of environmental stress.
7. Produce diagnoses on the status of the stocks.
8. Present and discuss assessment related woks.
9. Complete the filling up of the SCSA stock assessment forms including, when available, those for direct methods.
10. Evaluate the new assessment forms provided this year, in relation to the recommendations provided by the 2011 Assessment Working Groups and the SAC.
11. Suggest management advice to the SAC considering different alternatives

Appendix D

STOCK ADVICE TABLES

(This appendix includes the proposed tables to incorporate in the stock advice for small pelagics, as well as some explanations on how to fill them)

Please only use one of the two options, unidimensional or bidimensional stock advice summary. Also, if available fill Table 3 complete and add figures for historical trends on biomass, recruitment and Fbar.

Table 1: Unidimensional stock advice summary.

	Not known or uncertain. Not much information is available to make a judgment;
	Underexploited, undeveloped or new fishery. Believed to have a significant potential for expansion in total production;
	Moderately exploited, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production;
	Fully exploited. The fishery is operating at or close to an optimal yield level, with no expected room for further expansion;
	Overexploited. The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse;
	Depleted. Catches are well below historical levels, irrespective of the amount of fishing effort exerted;
	Recovering. Catches are again increasing after having been depleted or a collapse from a previous;
	None of the above.

Table 2: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
[STATE THE PERIOD]		[STATE THE PERIOD]	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table 3: Stock advice summary; Historical trends in biomass and recruitment

Biomass trends		Recruitment trends	
[STATE THE PERIOD]		[STATE THE PERIOD]	
[range(min – max)]		[range (min-max)]	
	Stable		Stable
	Increasing		Increasing
	Decreasing		Decreasing

Conceptual reference point refers to the period in the table. The two variables are being assessed independently. The values are related to conceptual reference points. Sustainable Fishing Mortality: refers to fishing mortality alone and to the conceptual reference point used (F_{MSY}, or F_{pa} or F_{lim}). If MSY then is the F that is expected to produce sustainable maximum yields in the future, if PA then that B is not expected to drop below BPA in the future.
In table 3, the range gives an idea on the magnitude of the fluctuations in the period in exam.

Appendix E

Stock Assessment Form:
Sardine GSA 01-03 (Alboran Sea)

SAC GFCM
Sub-Committee on Stock Assessment

Date*	**10**	**October**	**2012**	**Code***	**PIL99121*O**

Authors*: 1*Omar Kada, 1*My Hachem Idrissi and 2*Ana Giraldez

Affiliation*: 1* INRH (Centre Régional de Nador) 2* IEO (Centro de Malaga)

Species Scientific name*: ####*Sardina pilchardus - PIL*
Source: GFCM Priority Species

####
Source: -

####
Source: -

Geographical area*: Alboran Sea

Geographical Sub-Area (GSA)*: 99 - Combination of GSAs

Combination of GSAs		
	1	01 - Northern Alboran Sea
	2	03 - Southern Alboran Sea
	3	

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet #0 Basic data on the assessment

Code: PIL99121*O

Date*	10	Oct	2012	Authors*	1*Omar Kada, 1*My Hachem Idrissi and 2*Ana Giraldez

Species Scientific name*	Sardina pilchardus - PIL	Species common name*	European pilchard

Data Source

GSA*	01 - Northern Alboran Sea, 03 - Southern Alboran Sea	Period of time*	years 2003 to 2011

Description of the analysis

Type of data*	Age composition of commercial catches and official landings.	Data source*	INRH and IEO
Method of assessment*	Pseudo cohort analysis and yield per recruit analysis	Software used*	VIT (Lleonart and Salat, 1997)

Sheets filled out

B	P1	P2a	P2b	G	A1	A2	A3	Y	Other	D	Z	C
1	1	2	2	1	1	1	1	1	---	1	1	1

Comments, bibliography, etc. TEXT ONLY - Characheters left: 1025

Cadima E.L., 2001. Manuel d'évaluation des ressources halieutiques. FAO document technique. N° 393, FAO. 162p.

Lleonard J. et Salat, 2000. VIT for windows (version 1.2): software for fisheries analysis. Inf. tech. Sci.Mar.

N. El Ouamari et N. Abid, 2003. Etat d'exploitation du stock de la sardine en Méditerranée marocaine, SCES, Tanger, 2003.

O. Kada et N. El Ouamari, 2005. Etat d'exploitation du stock de la sardine en Méditerranée marocaine, SCES, Rome, 2005.

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet B Biology of the species

Code: PIL99121*O

Biology

Somatic magnitude measured (LH, LC, etc)*	total lenght	Units*	cm

Sex	Fem	Mal	Both	Unsexed		
Maximum size observed			25		Reproduction season	
Size at first maturity			13		Reproduction areas	Continental shelf
Recruitment size			6		Nursery areas	Continental

Parameters used (state units and information sources)

			Sex			
		Units	female	male	both	unsexed
Growth model	L∞				22,22	
	K				0,436	
	t0				-1,430	
	Data source	IEO Malaga				
Length weight relationship	a				0,0030	
	b				3,2	

M				0,5	

sex ratio (mal/fem)	

Comments TEXT ONLY - Characheters left: 1900

Data of growth and reproduction of sardine "Sardina pilchardus" are resulting from biological study.

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet P1 General information about the fishery

Code: PIL99121*O

Data source*	Size composition of landings from sampling	Year (s)*	average from 2003 to 2011
Data aggregation (by year, average figures between years, etc.)*	Conversion of distribution by lenght to a distribution by age		

Fleet and catches (please state units)

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	MAR	99	H - Purse Seine (12-24 metres)	02 - Seine Nets	31 - Small gregarious pelagic	PIL
Operational Unit 2	ESP	99	H - Purse Seine (12-24 metres)	02 - Seine Nets	31 - Small gregarious pelagic	PIL
Operational Unit 3						
Operational Unit 4						
Operational Unit 5						

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
MAR 99 H 02 31 - PIL	136	Tons	7083				b days*TJ
ESP 99 H 02 31 - PIL	100	Tons	6293				Effective
Total	236		13375.621				

Legal minimum size	50 ind/Kg (moule) in Moroccan and 11 cm in S

Comments To add TEXT and/or Chart please read carefully the NOTE on the left

Catch is the landings of sardine in GSA03 during the year 2011

The catch (landings) is not split by Fleet segments. It comprises 6293 Tons in 2011 for the two Operational Units in GSA01. Although landings are not still separated by Fleet segments we can provide a segmentation of the pelagic fleet in GSA01, with number of boats for every fleet segment:

The Fleet Segment G - Purse Seine (6-12 metres) comprises 12 boats in GSA01 in 2011
The Fleet Segment H - Purse Seine (12-24 metres) comprises 88 boats in GSA01 in 2011

Beacuse that landing aggregation we prefer to fill pages P2a and P2b considering the two fleet segments as an unique pelagic fleet.

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	**Sheet P2a** **Fishery by Operational Unit**

Code: PIL99121*O

Page 1 / 2

Data source*	Age composition of landings from Morocco	OpUnit 1*	MAR 99 H 02 31 - PIL

Time series

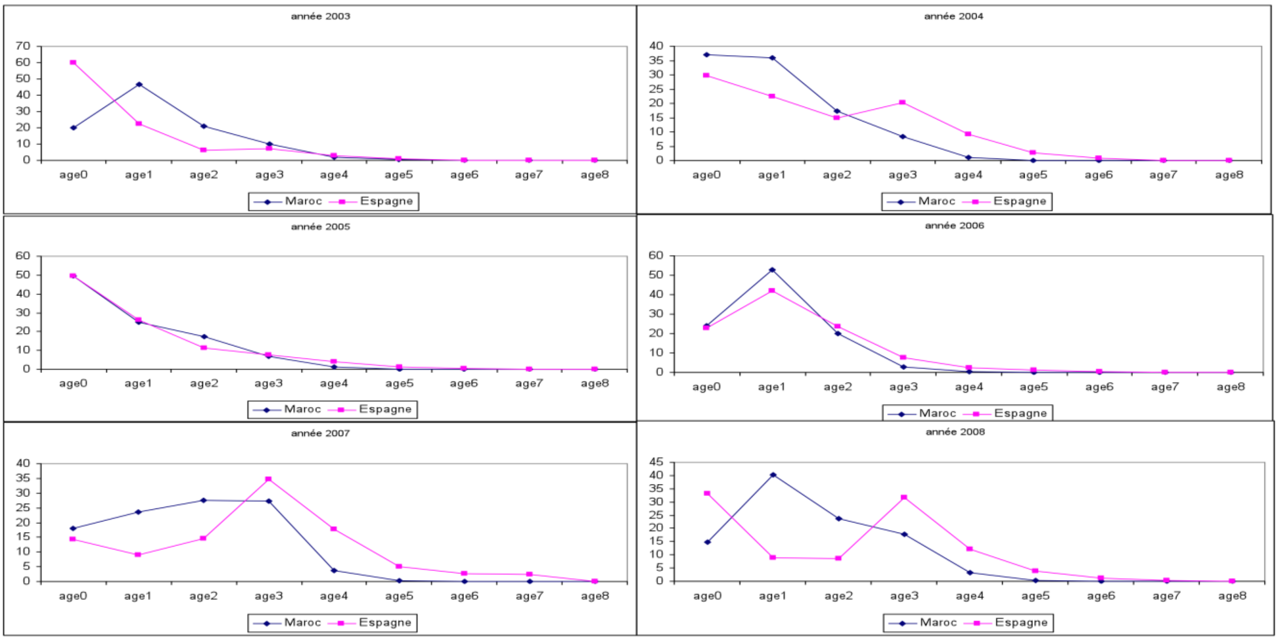
Year*	2003	2004	2005	2006	2007	2008
Catch	10671.863	12458.186	9228	5024.486	13574.112	9111.421
Minimum size	9	8	7	8.5	8	9
Average size Lc	16.35	15.39	14.8	15.37	16.53	16.66
Maximum size	22	21.5	21.5	21	22	23.5
Fleet	139	92	113	134	135	136

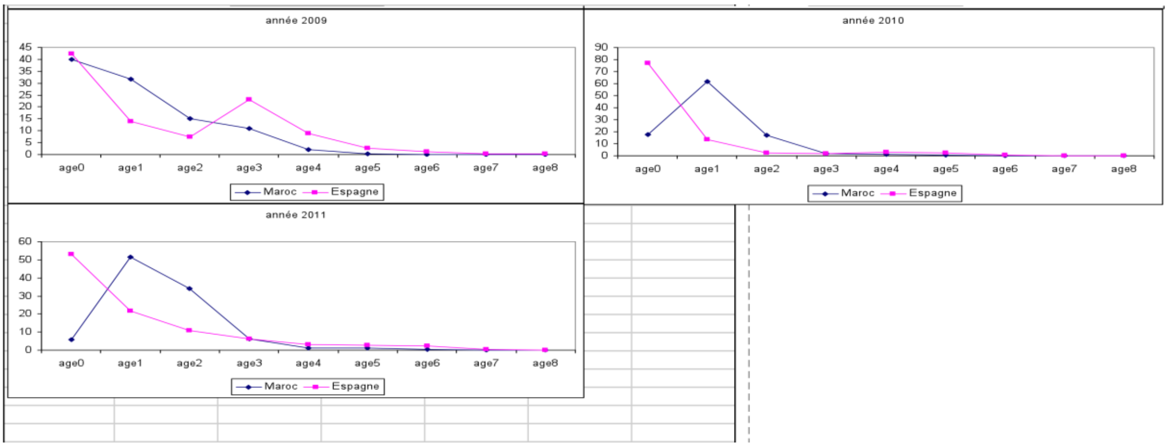
Year	2009	2010	2011			
Catch	15075.8855	11102.1255	7082.621			
Minimum size	10	8	10.5			
Average size Lc	15.37	16.03	16.9			
Maximum size	22.5	21	21			
Fleet	124	144	136			

Selectivity **Remarks** TEXT ONLY - Charachters left: 200

L25	
L50	13
L75	
Selection factor	

Structure en âge des débarquements Espagne Maroc (en %)





SAC GFCM - Sub-Committee on Stock Assessment (SCSA)

Assessment form

Sheet P2a
Fishery by Operational Unit

Code: PIL99121*O
Page 2 / 2

Data source*	Age composition of landings from Spain	OpUnit 2*	ESP 99 H 02 31 - PIL

Time series

Year*	2003	2004	2005	2006	2007	2008
Catch	8514	4005	7562	9622	6735	4489
Minimum size	8	6.4	6.5	10.8	9.8	8
Average size Lc	14.4	16.0	15.5	16.5	17.5	17.5
Maximum size	22.5	23.5	22.6	22.3	22.8	23.2
Fleet	167	160	149	135	136	131

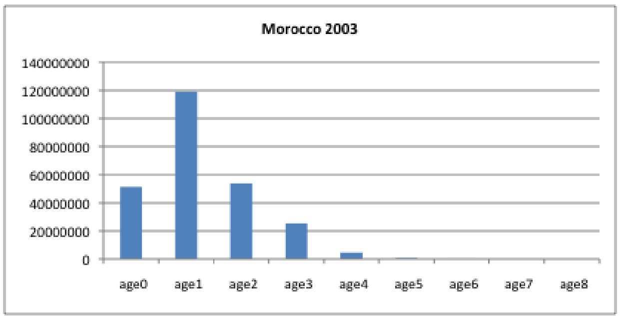
Year	2009	2010	2011			
Catch	6013	7349	6293			
Minimum size	9.5	7.0	9.0			
Average size Lc	15.5	13.1	14.9			
Maximum size	23.5	23.5	23.5			
Fleet	113	104	100			

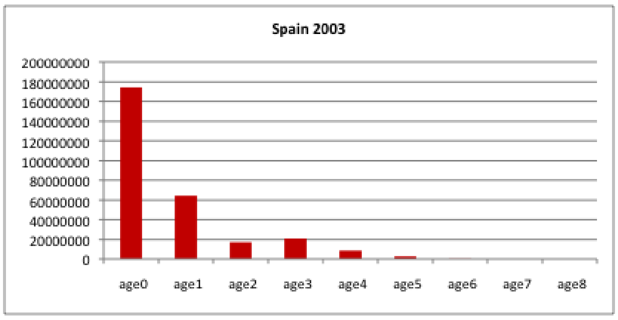
Selectivity

L25	
L50	12,02 cm in 2011
L75	
Selection factor	

Remarks

TEXT ONLY - Characheters left:	200


Morocco 2003
140000000
120000000
100000000
80000000
60000000
40000000
20000000
0
age0 age1 age2 age3 age4 age5 age6 age7 age8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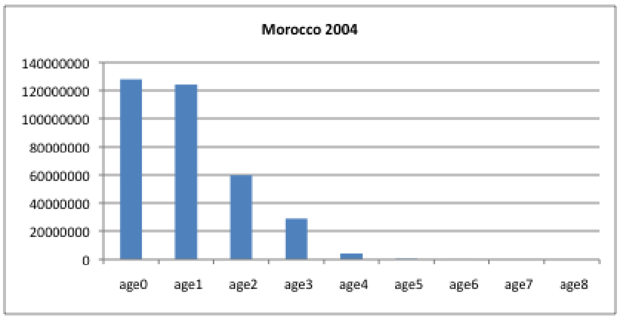
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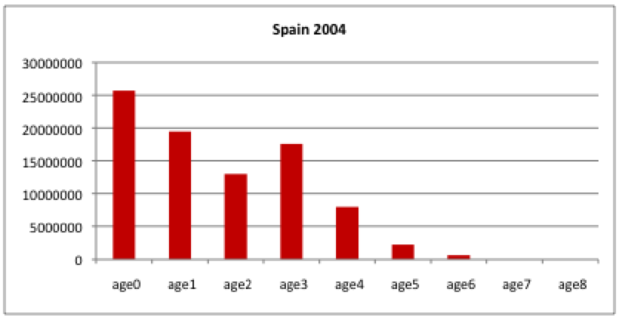
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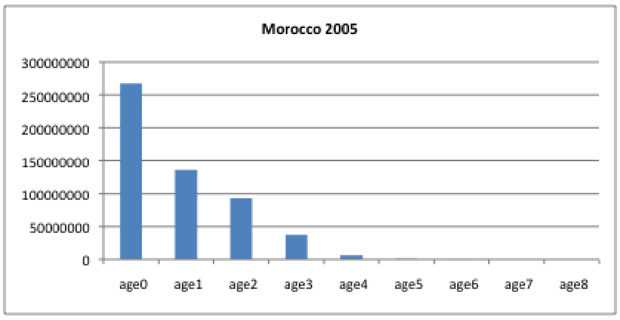
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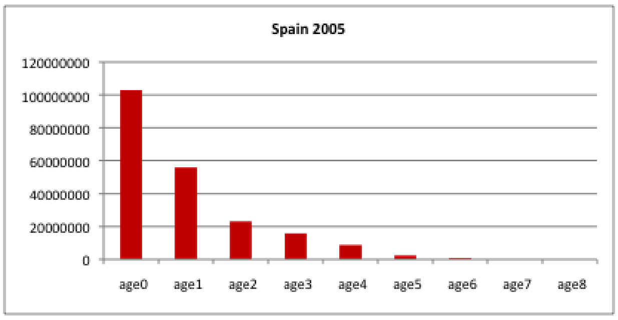
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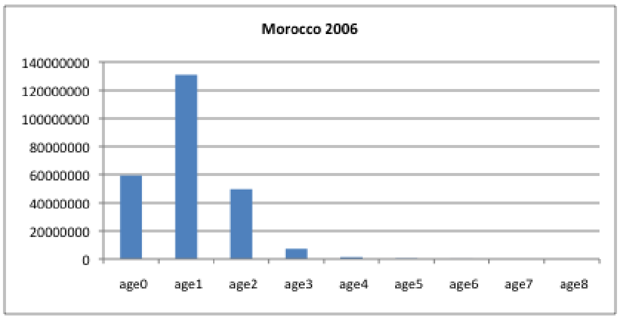
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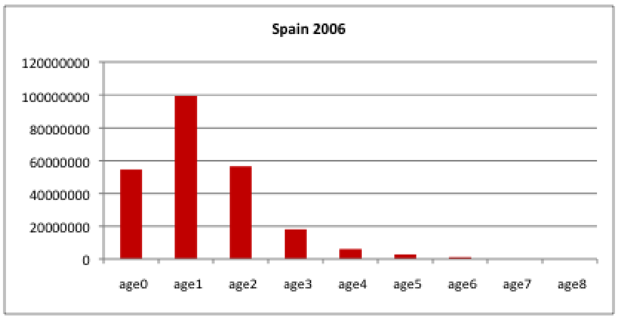
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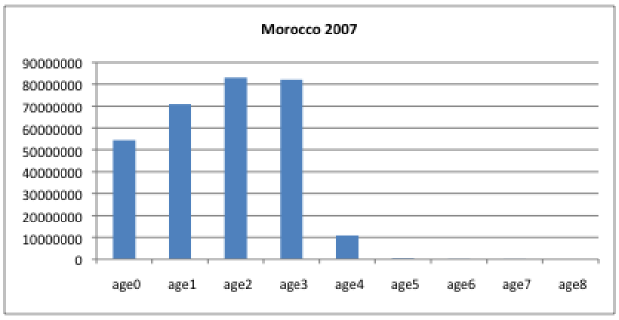
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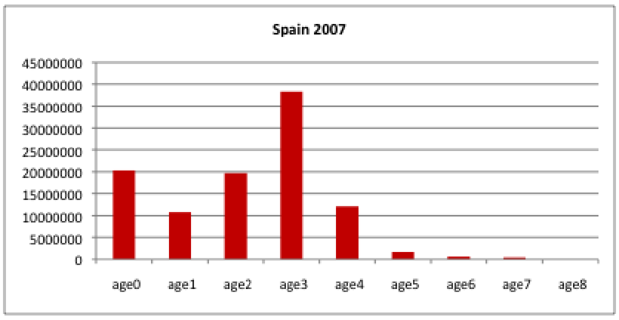
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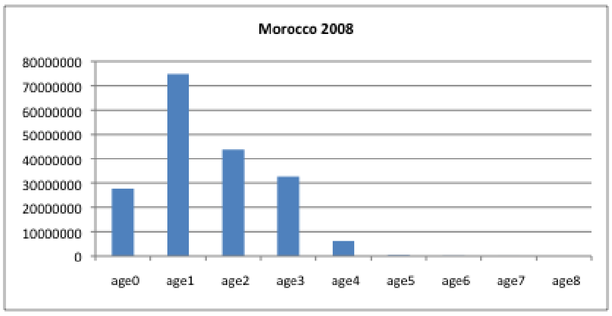
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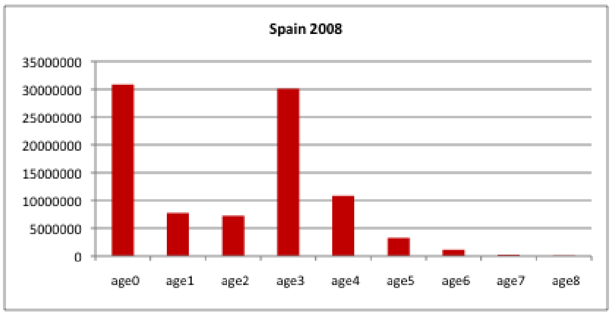
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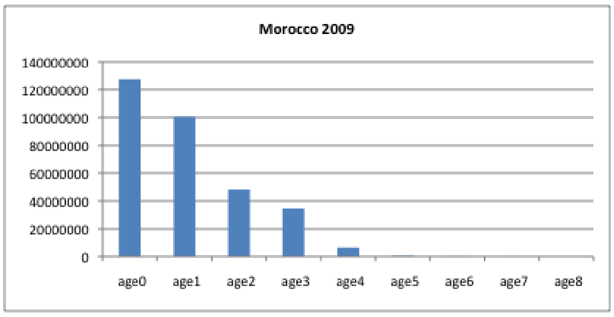
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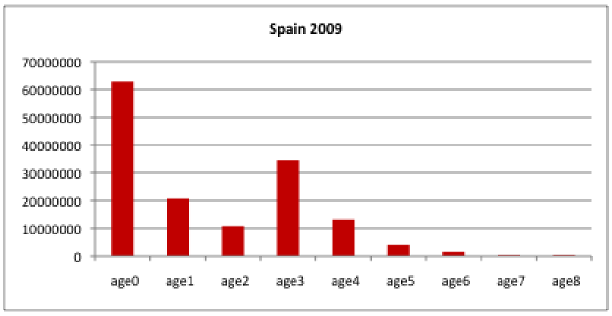
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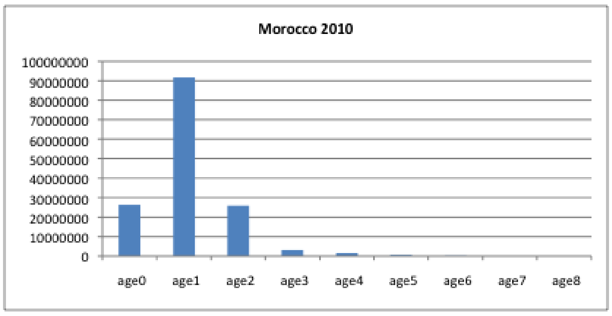
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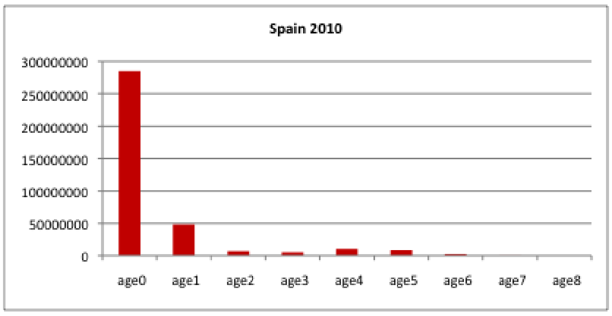
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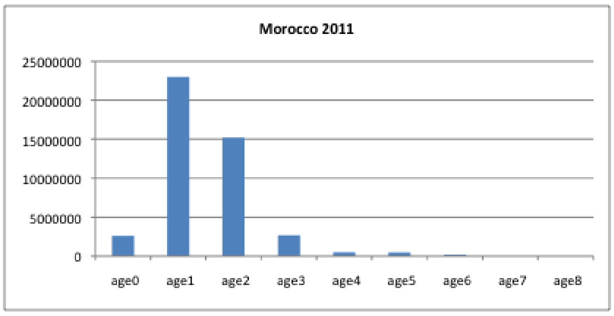
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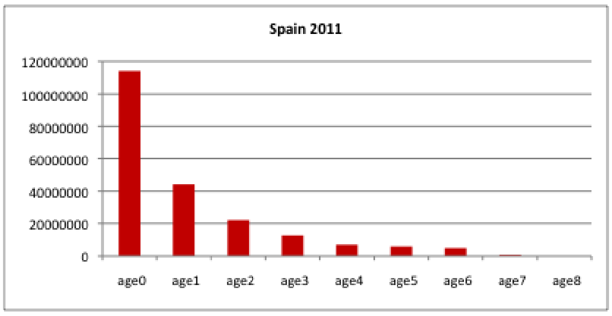
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SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet P2b Fishery by Operational Unit

Code: PIL99121*O

Page 1 / 2

Data source*	Morocco	OpUnit 1*	MAR 99 H 02 31 - PIL

Regulations in force and degree of observance of regulations

To add TEXT and/or C
read carefully the NOT

- Fishing license: fully observed
- Mesh size (11 mm stretched): not fully observed
- Moule (50 individuals/Kg): fully observed.

Accompanying species

To add TEXT and/or Chart please read carefully the NOTE on

The accompagning species of sardine are:
- Anchois "Engraulis encrasicolus"
- Chinchards " Trachurus trachurus" and "T. mediterraneus"
- Bogue "Boops boops"
- Sardinelle "Sardinella aurita"
- Maquereau "Scomber scombrus"

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)

Assessment form — **Sheet P2b** — **Fishery by Operational Unit**

Code: PIL99121*O

Page 2 / 2

Data source*	Spain	OpUnit 2*	ESP 99 H 02 31 - PIL

To add TEXT and/or Chart please read carefully the NOTE

Regulations in force and degree of observance of regulations

Fishing license: fully observed
Minimum landing size 11cm: not fully observed (Some landings under minimum size in some specific ports).
No fishing allowed on weekend. Time at sea 12 hours per day and 5 days a week: fully observed
Several technical measures regulations (gear and mesh size, engine, GRT, etc...): not fully observed

Accompanying species

To add TEXT and/or Chart please read carefully the NOTE on

The most important are:
Anchovy (*Engraulis encrasicolus*)
Mediterranean Horse Mackerel (*Trachurus mediterraneus*)
Other Horse Mackerels (*Trachurus trachurus* and *Tachurus picturatus*)
Mackerel (*Scomber scombrus*)
Chub Mackerel (*Scomber japonicus*)
Round sardinella (*Sardinella aurita*)
Bogue (*Boops boops*)

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet G Indirect methods. Global model

Code: PIL99121*O

Analysis #*	1

Page 1 / 1

Data source*	Morocco (reste l'Espagne)	Gear*	Purse Seine

Model characteristic

Type of model*	Structural model "VPA"	Fitting criterion	
Software	VIT	Bibliographical source	Lleonart and Salat, 1997

Data

Year	2003	2004	2005	2006	2007	2008	2009
Catch	10671.863	12458.186	9228	5024.486	13574.112	9111.421	15075.886
Effort	269756	282442	451549	324738	589958	362405	335355
CPUE	0.015	0.03	0.02	0.015	0.023	0.029	0.053

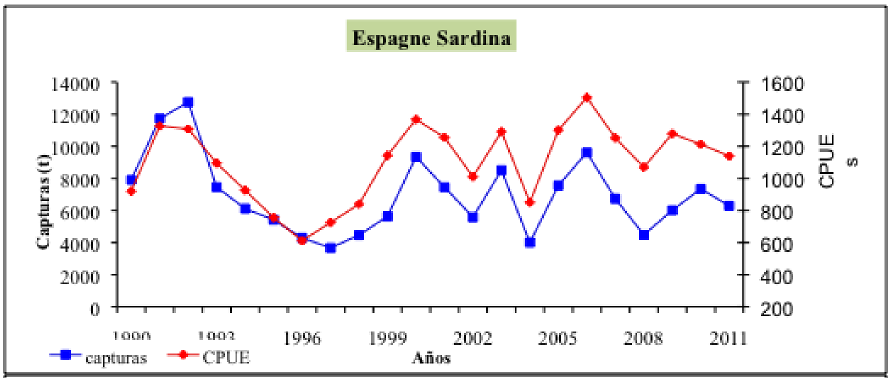
Year	2010	2011					
Catch	11102.126	7082.621					
Effort	728277	353818					
CPUE	0.015	0.02					

Adjustment

RMS	

Results

Carryng capacity		a	
Growth rate		b	
Catchability			
MSY			
EMSY		TACMSY	
E0.1		TAC0.1	
Ecurrent			


Espagne Sardina
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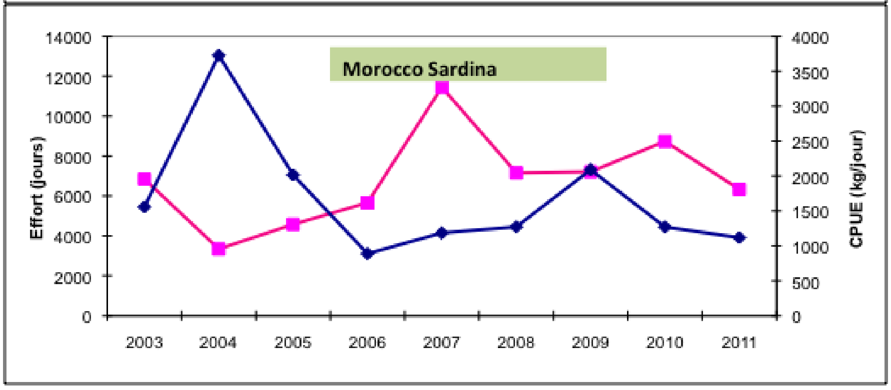

Morocco Sardina
14000
12000
10000
8000
6000
4000
2000
0
Effort (jours)
4000
3500
3000
2500
2000
1500
1000
500
0
CPUE (kg/jour)
2003
2004
2005
2006
2007
2008
2009
2010
2011

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet G Indirect methods. Global model

Code: PIL99121*O

Analysis #*	

Page 2 / 1

Data source*	Spain	Gear*	Purse Seine

Model characteristic

Type of model*	Structural model "VPA"	Fitting criterion	
Software	VIT	Bibliographical source	Lleonart and Salat, 1997

Data

Year	2003	2004	2005	2006	2007	2008	2009
Catch	8514	4005	7562	9622	6735	4489	6013
Effort							
CPUE	1292	851	1302	1505	1252	1070	1279

Year	2010	2011					
Catch	7349	6293					
Effort							
CPUE	1213	1140					

Adjustment

RMS	

Results

Carryng capacity		a	
Growth rate		b	
Catchability			
MSY			
EMSY		TACMSY	
E0.1		TAC0.1	
Ecurrent			

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)

Assessment form

Sheet A1
Indirect methods: VPA, LCA

Code: PIL99121*O
Page 1 / 1

Sex*	both

Analysis # *	1

Time series

Data	Size	Age
(mark with X)		X

Model	Cohorts	Pseudocohorts
(mark with X)		X

Equation used		Tunig method	
# of gears	1	Software	VIT (Lleonart and Salat, 1997)
$F_{terminal}$	0.4		

Population results (please state units)

	Sizes	Ages		Amount	Biomass
Minimum		0 year	Recruitment		7190 tons
Average			Average population		31879 tons
Maximum		6+ year	Virgin population		
Critical	14.518 cm	1 year	Turnover		
					SSB
					15636 tons

Average mortality

	Total	Gear					
F_1	0.381						
F_2							
Z	0.881						

(F1 and F2 represent different possible calculations. Please state them)

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet A2 Indirect methods: data

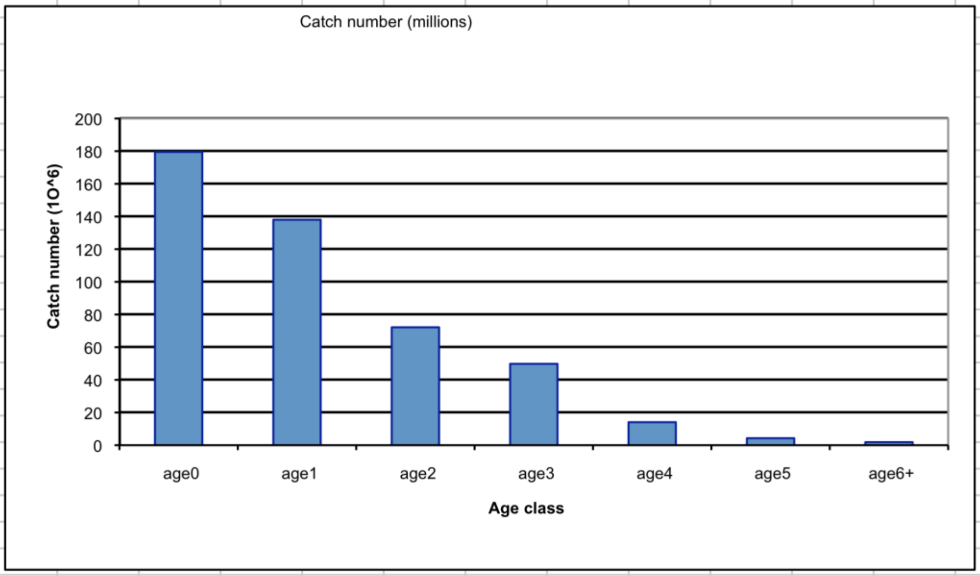
Code: PIL99121*O

Sex*	both	Gear*	purse seine	Analysis # *	1

Data	A pseudo cohort created using Spanish and Morocan data from 2003 to 2011

Data

To add TEXT and/or Chart please read carefully the NOTE on the left



SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet A3 Indirect methods: VPA results

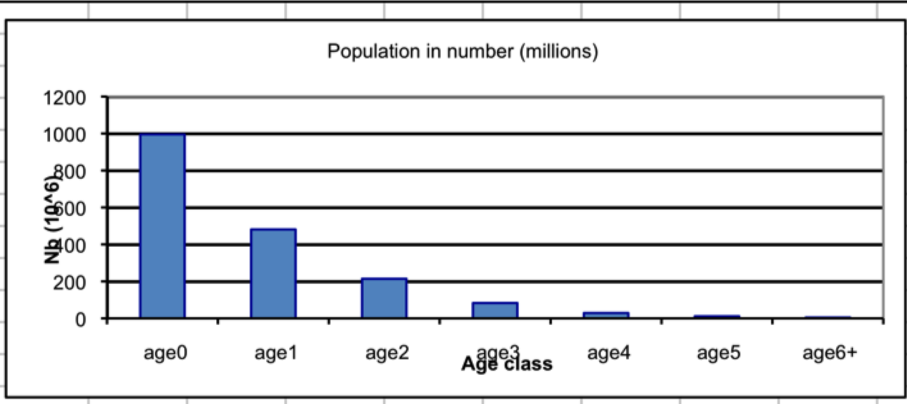
Code: PIL99121*O

Page 1 / 1

Sex*	both	Gear*	purse seine	Analysis #*	1

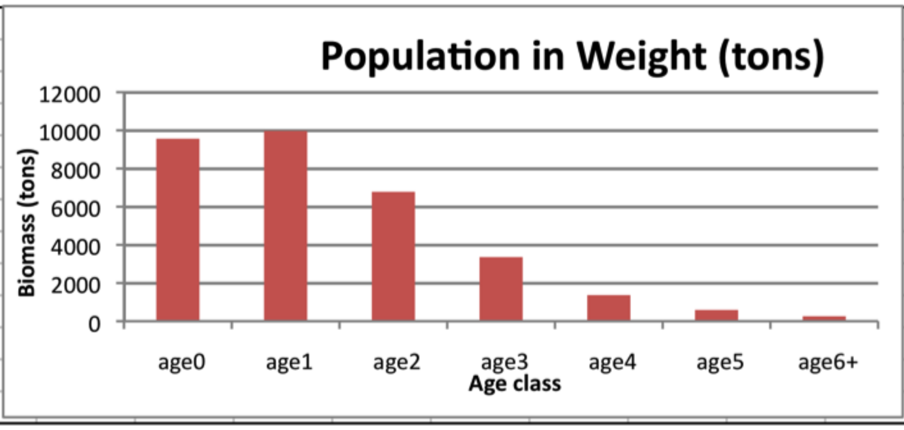
Population in figures

To add TEXT and/or Chart please read carefully the NOTE on the



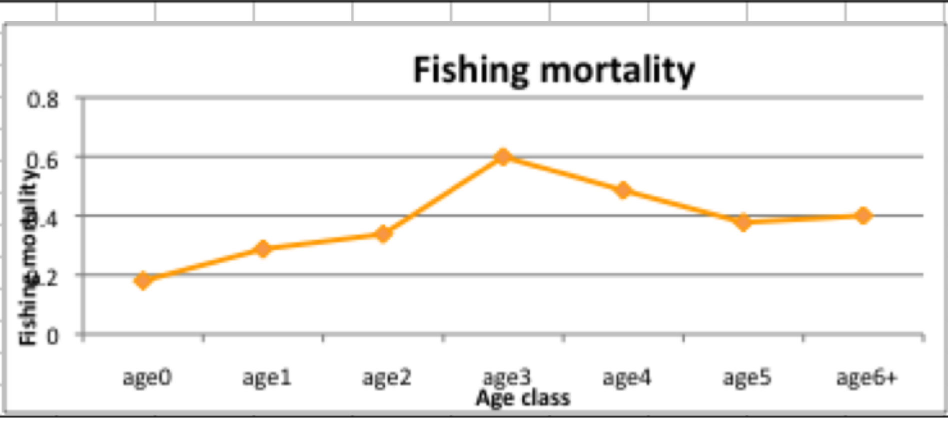
Population in biomass

To add TEXT and/or Chart please read carefully the NOTE on the



Fishing mortality rates

To add TEXT and/or Chart please read carefully the NOTE on the



SAC GFCM - Sub-Committee on Stock Assessment (SCSA)

Assessment form

Sheet Y
Indirect methods: Y/R

Code: PIL99121*O

Sex	both		Analysis #	1

# of gears	purse seine	Software	VIT

Parameters used

Vector F	
Vector M	
Vector N	

Model characteristics

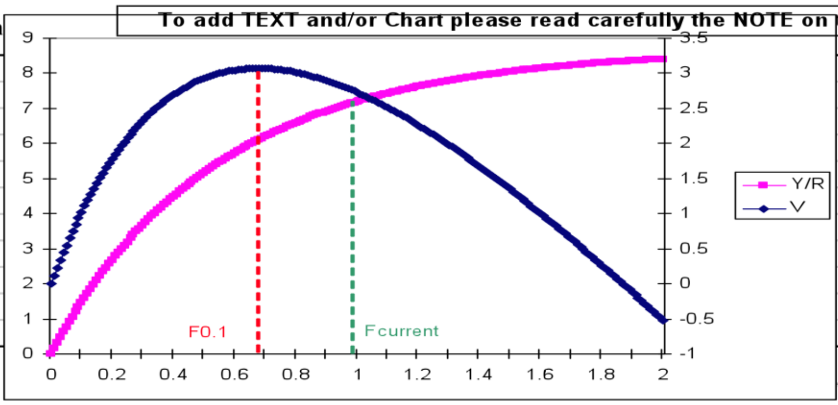
To add TEXT and/or Chart please read carefully the NOTE on

Results

	Total	Gear			
Current YR	7.191				
Maximum Y/R	--				
Y/R 0.1	6.107				
F_{max}	--				
$F_{0.1}$	0.68				
Current B/R	23.233				
Maximum B/R	--				
B/R 0.1	27.607				

Com

To add TEXT and/or Chart please read carefully the NOTE on the left



et Y (page 2)

Comments

To add TEXT and/or Chart please read carefully the NOTE on the left

V is function to calculate F0.1 (Cadima, 2003)

We maximaise this function: Vi = (Y/R)i - (0.1*(B/R)o*Fi)

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	Sheet D Diagnosis

Code: PIL99121*O

Indicators and reference points

Criterion	Current value	Units	Reference Point	Trend	Comments
B					
SSB					
F					
Y					
CPUE					
E=F/Z	0.43		0.4		Exploitation rate (Patterson, 1992)

Stock Status* Use one (or both) of the following two systems for the stock assessment status description

Unidimensional

○	? - (or blank) Not known or uncertain. Not much information is available to make a judgment;
○	U - Underexploited, undeveloped or new fishery. Believed to have a significant potential for expansion in total production;
○	M - Moderately exploited, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production;
○	F - Fully exploited. The fishery is operating at or close to an optimal yield level, with no expected room for further expansion;
◉	O - Overexploited. The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse;
○	D - Depleted. Catches are well below historical levels, irrespective of the amount of fishing effort exerted;
○	R - Recovering. Catches are again increasing after having been depleted or a collapse from a previous;
○	NONE

Bidimensional

Exploitation rate

○	No or low fishing mortality
○	Moderate fishing mortality
◉	High fishing mortality
○	Uncertain / Not assessed
○	NONE

Stock abundance

○	Virgin or high abundance
◉	Intermediate abundance
○	Low abundance
○	Depleted
○	Uncertain / Not assessed
○	NONE

Sheet D (page 2)

Comments TEXT ONLY - Charachters left: 3508

The result of the joint analysis showed that the fishing effort is mainly exercised on adult individuals (age 3 and age 4).

The analysis of the yield per recruit indicate that the stock of sardine in the alboran Sea (GSA01 and GSA03) is overexploited. (F0.1 = 0.68)

The average exploitation rate is estimated to 0.43 (very close to the threshold F/Z = 0.4 suggested as biological reference point for small pelagics (Patterson, 1992)). The exploitation rate can be considered moderate.

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)

Assessment form — **Sheet Z** — **Objectives and recommendations**

Code: PIL99121*O

Management advice and recommendations*

TEXT ONLY - Characheters left:	3646

This assessment suggestions should be taken as preliminary and cautionary, as this VIT assessment for this area is based on an average of short time series of data and between two countries.

This fishery is considered as overexploited. We advise to reduce the level of the fishing mortality by 30%. This can be obtained by reducing the fishing effort.

I

SAC GFCM - Sub-Committee on Stock Assessment (SCSA)

Assessment form — **Sheet C** — **Comments**

Code: PIL99121*O

Page 1 / 1

Comments*

TEXT ONLY - Characheters left:	3236

Conclusions - Assessment :

This assessment suggestions should be taken as preliminary and cautionary, as this VIT assessment for this area is based on an average of short time series of data and between two countries.

The result of the joint analysis showed that the fishing effort is mainly exercised on adult individuals (age 3 and age 4).

The analysis of the yield per recruit indicate that the stock of sardine in the alboran Sea (GSA01 and GSA03) is overexploited. ($F0.1 = 0.68$)

The average exploitation rate is estimated to 0.43 (very close to the threshold $F/Z = 0.4$ suggested as biological reference point for small pelagics (Patterson, 1992)). The exploitation rate can be considered moderate.

Abstract for SCSA reporting

Authors 1*Omar Kada, 1*My Hachem Idrissi and 2*Ana Giraldez

Year 2012

Species Scientific name Sardina pilchardus - PIL
Source: GFCM Priority Species

Source: -

Source: -

Geographical Sub-Area 01 - Northern Alboran Sea, 03 - Southern Alboran Sea

Fisheries (brief description of the fishery)* **TEXT ONLY - Characheters left: 800**

Sardine (Sardina pilchardus) and anchovy (Engraulis encrasicolus) are the main target species of the purse seine fleet in Southern and Northerm Alboran Sea (GSA03 and GSA01), but other species with lower economical importance are also captured, sometimes representing a high percentage of the capture: horse mackerel (Trachurus spp.), mackerel (Scomber spp.) and gilt sardine (Sardinella aurita).

The current fleet GSA01 the Northerm Alborán Sea is composed by 100 units, caracterised by small vessels. 12% of them are smaller than 12 m and 88 % between 12 and 24 m. The purse seine fleet has been continuously decreasing in the last who decades, fron more 230 vessels in 1980 to 100 in 2011.

Source of management advice* **TEXT ONLY - Characheters left: 1056**

(brief description of material -data- and methods used for the assessment)

Fishery assessment by VIT method of the sardine stock in GSA01 and GSA03 is shown. VIT software was used for the assessment.

Data used:
Landings from 2003-2011 from all Fishery ports from GSA01 and GSA03.
Combined ALKs 2003-2011 for all the years (except 2009) from GSA01.
Length distribution 2003-2011.
Lenght distributions were converted to age distributions.

Biological sampling 2011 for Weight-Length relationships (GSA01).

Stock Status*

O - Overexploited. The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse;

Exploitation rate

High fishing mortality

Stock abundance

Intermediate abundance

Comments

The result of the joint analysis showed that the fishing effort is mainly exercised on adult individuals (age 3 and age 4).

The analysis of the yield per recruit indicate that the stock of sardine in the alboran Sea (GSA01 and GSA03) is overexploited. (F0.1 = 0.68)

The average exploitation rate is estimated to 0.43 (very close to the threshold F/Z = 0.4 suggested as biological reference point for small pelagics (Patterson, 1992)). The exploitation rate can be considered moderate.

Management advice and recommendations*

This assessment suggestions should be taken as preliminary and cautionary, as this VIT assessment for this area is based on an average of short time series of data and between two countries.

This fishery is considered as overexploited. We advise to reduce the level of the fishing mortality by 30%. This can be obtained by reducing the fishing effort.

Advice for scientific research*

- Include data from the algerian coast (GSA04) in order to cover all the Alboran Sea.

Stock Assessment Form

Sardine in GSA 07 (Gulf of Lion)

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Sardina pilchardus	Sardine	35
1st Geographical sub-area:	2nd Geographical sub-area:	3rd Geographical sub-area:
GSA07 gulf of Lions		
1st Country	2nd Country	3rd Country
France		
Stock assessment method: (direct, indirect, combined, none)		
direct		
Authors:		
Jean Louis Bigot, Jean Hervé Bourdeix, David Roos, Claire Saraux		
Affiliation:		
IFREMER BP171 Av. Jean Monnet 34203 SETE CEDEX (France)		

2 Stock identification and biological information

2.1 Stock unit

The assessment covers the whole GSA07 area corresponding to the Gulf of Lions. However, we think that the Gulf of Lions do not correspond to a complete stock unit. Indeed, hydrological exchanges between the Gulf of Lions and the Catalan Sea for instance are well known, which should at least affect larval transport and then recruitment of juvenile anchovies in both areas. Similarly, part of the young recruited in the Gulf of Lions sardine population may come from larval transport from spawners of the Ligurian Sea. Further, preliminary genetic analyses have shown no differences between Spanish and French stocks of sardines in the North-Western Mediterranean Sea.

2.2 Growth and maturity

Table 2.1:Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*					Units*	
Sex	Fem	Mal	Both	Unsexed		
Maximum size observed	20.5	19			Reproduction season	Winter-Spring
Size at first maturity	12	12			Reproduction areas	Offshore Rhone river
Recruitment size				7	Nursery areas	Coastal and lagoons

*Maximum size observed corresponds to the maximum size ever observed in a PELMED campaign

Table 2.2: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**both**	**unsexed**
Growth model	**L_∞**	cm	20.4	18.9		
	K	Year^{-1}	0.31	0.34		
	t_0	Year	-1.158	-1.047		
	Data source	DCF				
Length weight relationship	**a**					0.0026
	b					3.3888
	M (vector by length or age)					
	sex ratio (% females/total)					

Separate length-weight relationships for recruits and adults are given by:
For large sardines (i.e. > 11.5cm): a = 0.0065 and b = 3.0495
For small sardines (i.e. ≤ 11.5cm): a = 0.0026 and b = 3.3917
These two categories (recruits and adults) were based on the 2 modes observed in the length distribution of the population in 2012.
Length-weight relationship parameters are derived from data collected in 2012 only

Fisheries information

3.1 *Description of the fleet*

Table 3.1: Description of operational units in the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	FRA	07	E – Trawl (12-24 m)	03 - Trawls	31-Small gregarious pelagic	PIL
Operational Unit 2	FRA	07	H – Purse Seine (12-24 m)	02 – Seine Nets	31-Small gregarious pelagic	PIL

Table 3.2: Catch, bycatch, discards and effort by operational unit

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
FRA 07 E 03 31 -PIL	7	Tons	389	Anchovy	No discards	Spratus spratus	Nb boats
FRA 07 H 02 31 - PIL	3	Tons	368	Anchovy	No discards		Nb boats
Total	10						

Table 3.3: Catches as used in the assessment

Classification	Catch (tn)
Total	

3.2 Historical trends

Figure 3.1: Number of French sardine catches (in tons, red line and right axis) and boats operating on small pelagics (green line, left axis) in the Gulf of Lions from 1999 to 2012.

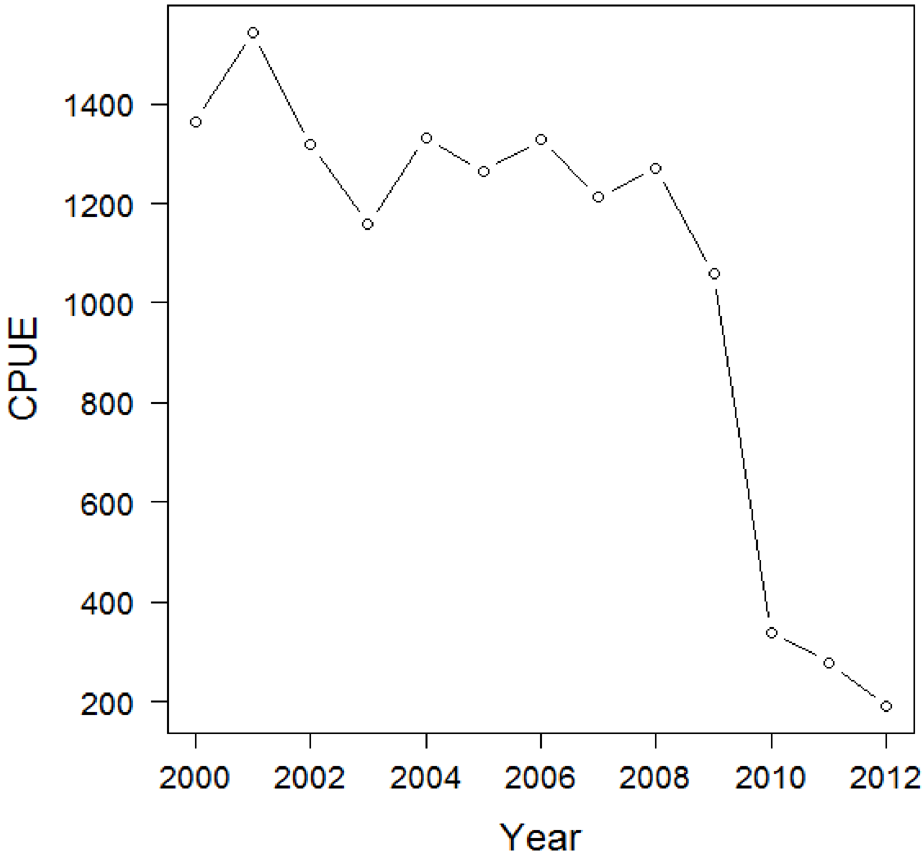


Figure 3.2: Catches per unit effort defined as the catches in tons divided by the cumulative number of fishing days from 2000 to 2012.

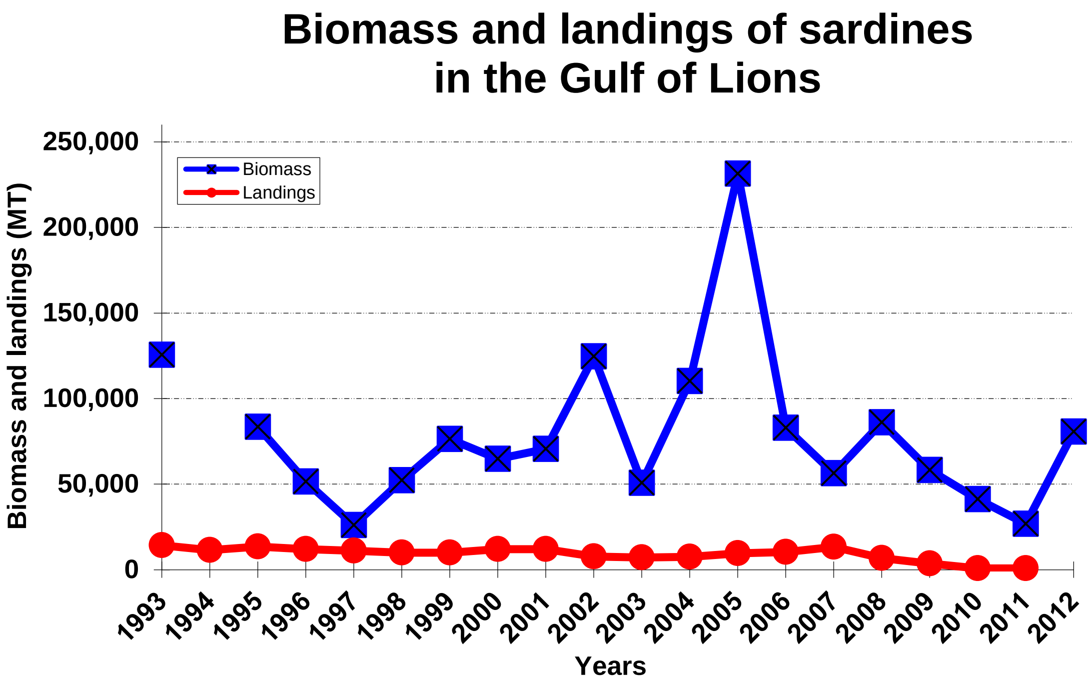


Figure 3.3: Biomass (in tons, blue line) and landings (in tons, red line) of sardines in the Gulf of Lions from 1993 to 2012.

2.1 Management regulations

- Exclusive licence for trawling, with a given number each year (both for small pelagics and demersals) - fully respected
- Limited engine power for trawlers to 318 kW or 430 hp - not respected
- Length of fishing trawlers inferior to 25 meters - fully respected
- Fishing effort limitations:
    - No fishing on Saturdays and Sundays, authorised hours trip: 3.00am to 8.00pm - fully respected
    - Trawling forbidden from coast to 3NM - not fully respected
    - Professional organisation regulations: Additional holidays: on average 40 days/year - fully respected

2.2 Reference points

Table 4.1: List of reference points

Criterion	Current value	Units	Referenc e Point	Tren d	Comments
B					
SSB					
F					
Y					
CPUE					

3 Fisheries independent information

3.1 Direct acoustic method

3.1.1 Brief description of the chosen method and assumptions used

Sampling was performed along 9 parallel and regularly interspaced transects (inter-transect distance = 12 nautical miles, see map below). Acoustic data were obtained by means of echosounders (Simrad ER60) and recorded at constant speed of 8 $nm.h^{-1}$. The size of the elementary distance sampling unit (EDSU) was 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output (Simmons & MacLennan 2005). Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a 30 min-trawl at 4 $nm.h^{-1}$ in order to evaluate the proportion of each species (by randomly sampling and sorting of the catch before counting and weighing each individual species). While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminarily treated with Movies + software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts.

Table 4.1: Acoustic cruise information.

Date	27 June 2012 – 31 July 2012		
Cruise	PelMed 2012	**Cruise**	PELMED12
Target species	Anchovies-Sardines		
Sampling strategy	9 // transect spaced 12 Nm		
Sampling season	Summer		
Investigated depth range (m)	10-200m		
Echo-sounder	ER60 38 KHz for assessment 70, 120 and 200 used as complementary frequency		
Fish sampler	Pelagic trawl 4FF176 with 7 m of vertical opening 4PM159 with 16 m of vertical opening		
Cod –end mesh size as opening (mm)	9 mm of mesh side; 18 mm of mesh size		
ESDU (i.e. 1 nautical mile)	1 Nm		
TS (Target Strength)/species	- 71.2 for anchovy and sardine		
Software used in the post-processing	Movies+ and R scripts		
Samples (gear used)	Pelagic trawl		
Biological data obtained	Length-Weight relationship, Age, Sex, Maturity (not yet assessed for 2012)		
Age slicing method	otolith		
Maturity ogive used			

Table 4.2: Acoustic results, if available by age or length class

	Biomass in metric tons	fish numbers	Nautical Area Scattering Coefficient	Indicator …	Indicator …
Sardines	80 537	9 370.835 million			
Anchovies	39 061	5 142.302 million			
Sprat	70 263	14 649.016 million			

This corresponds to the abundance and biomass of the whole sampled area

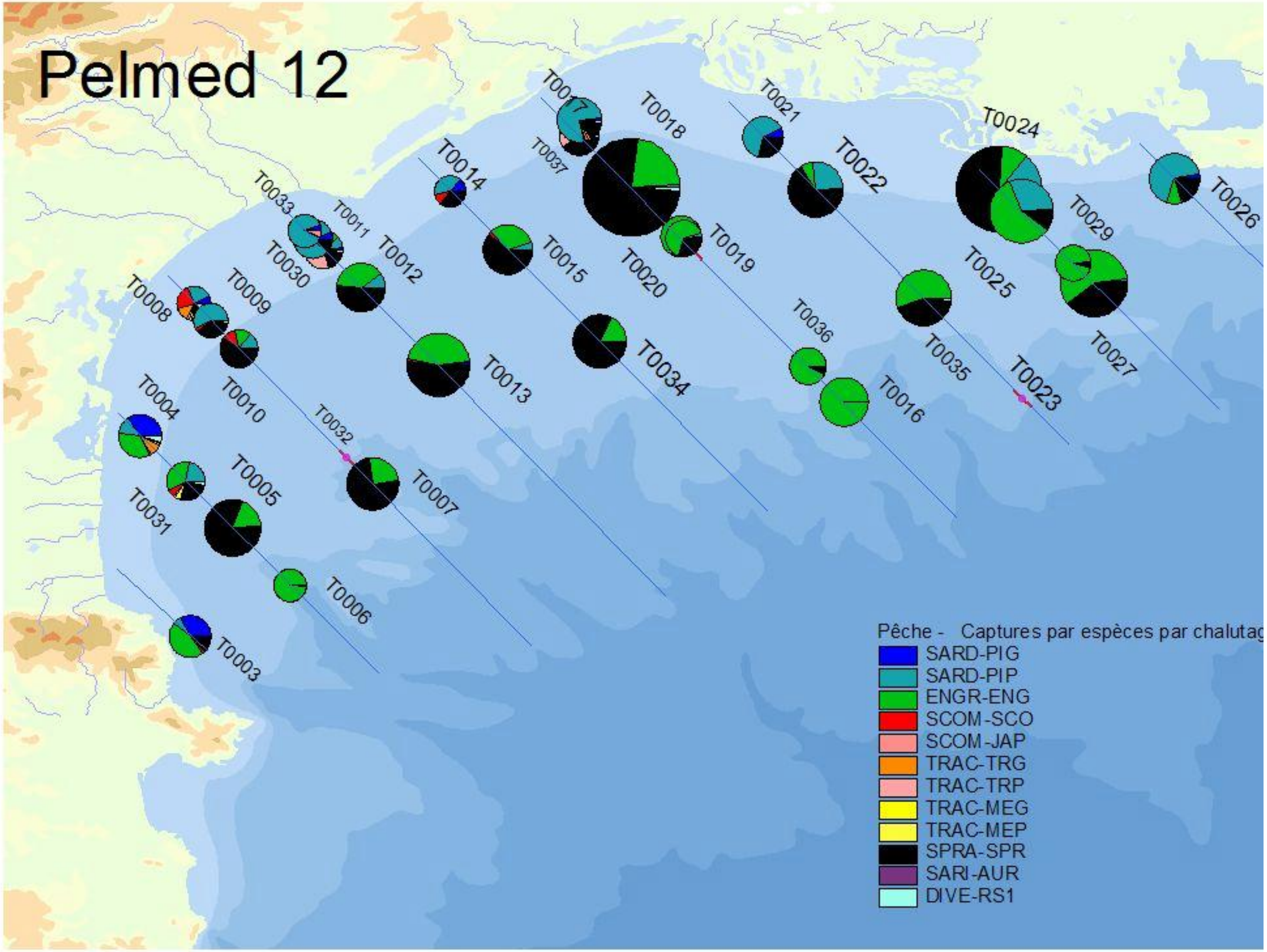


Figure 4.1: Map of the 2012 PELMED Campaign, survey performed in July 2012 to estimate small pelagic fish biomass in the Gulf of Lions. Lines represent the 9 parallel transects along which the acoustic survey is performed, while pies represent the trawls performed and the species distribution in the trawls. Sardines are represented in blue (light blue for small ones, under the 13cm commercial size and dark blue the big ones). Other major small pelagic species are also represented, in green for anchovies and black for sprats. The size of the pie is indicative of the total weight fished per trawl (on a logarithmic scale).

3.1.2 Spatial distribution of the resources

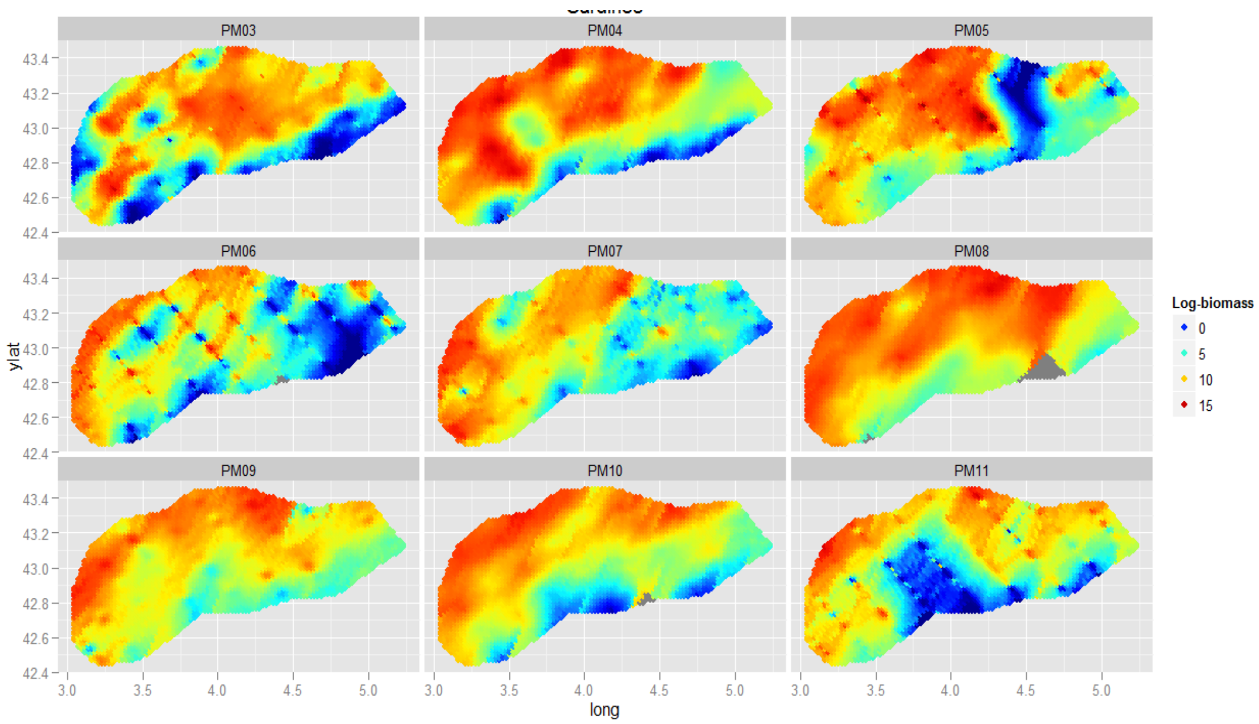


Figure 4.2: Sardine biomass distribution on a log-scale based on kriging methods for the 2003-2011 period.

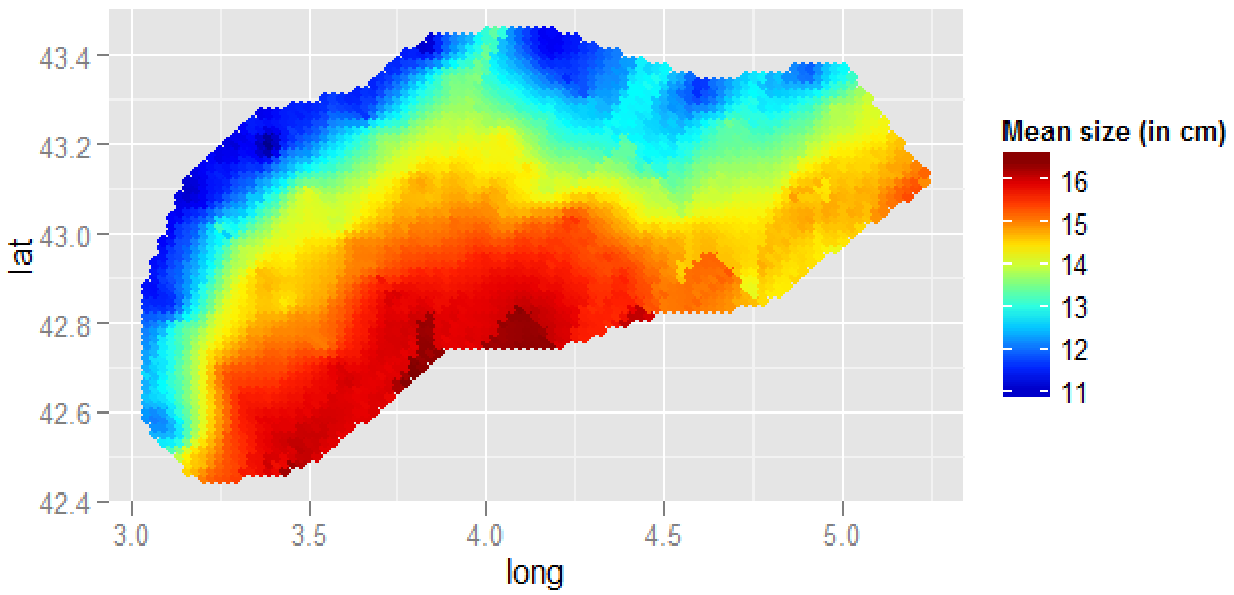


Figure 4.3: Average mean size distribution based on kriging methods (average from 2003 to 2011).

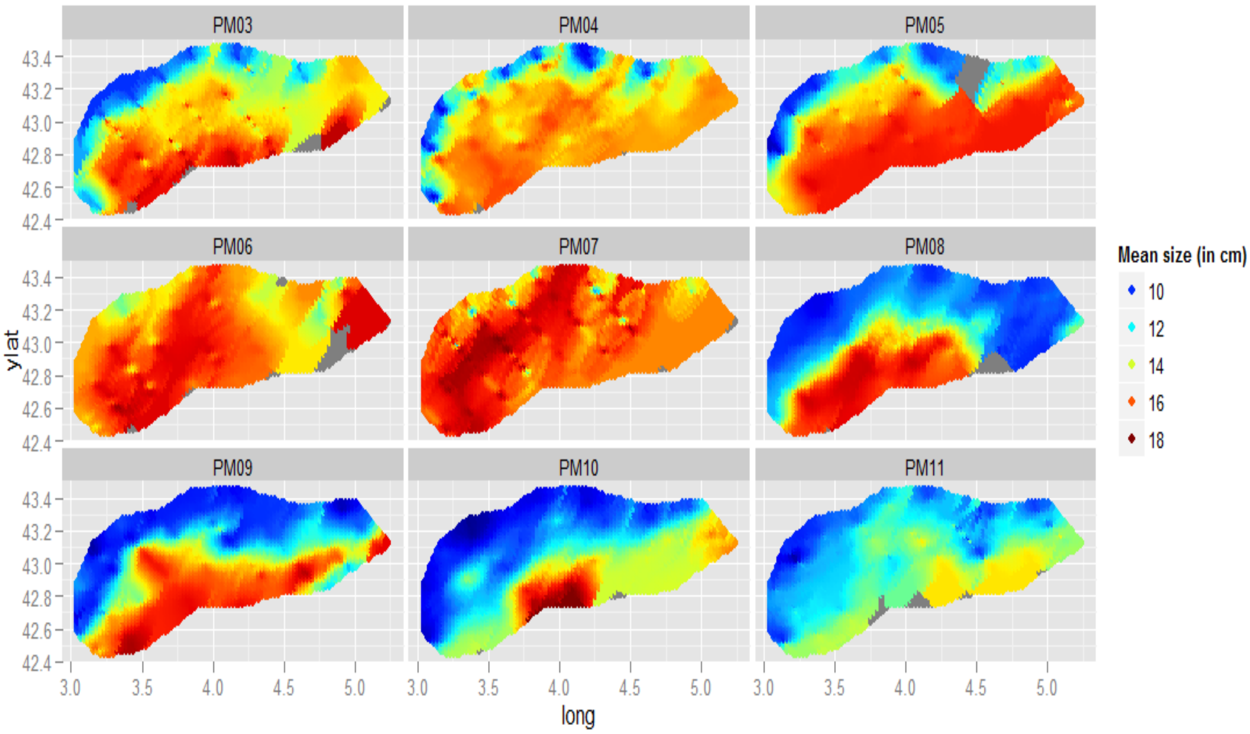


Figure 4.4: Mean size distribution based on kriging methods for the 2003 – 2011 period.

3.1.3 Historical trends

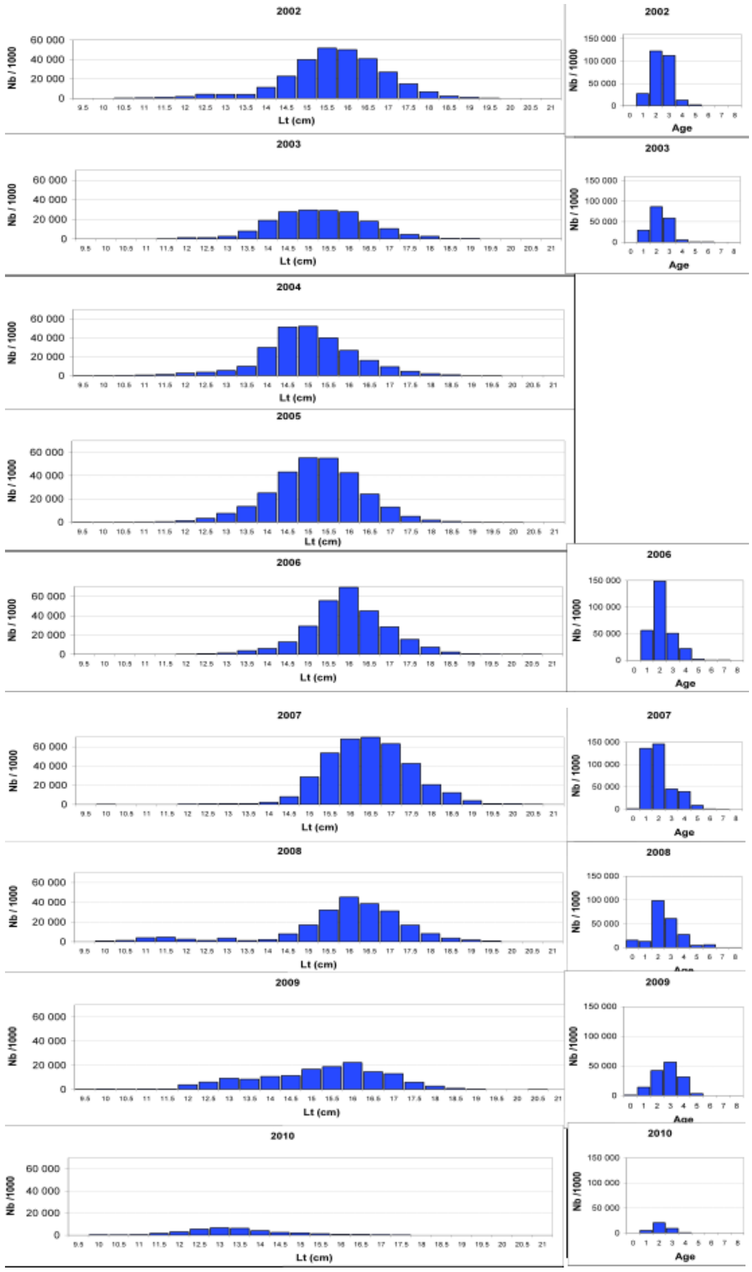


Figure 4.5: Size (on the right) and age (on the left) distribution of sardines sampled during the PELMED summer campaigns from 2002 to 2010.

4 Ecological information

5.1 Protected species potentially affected by the fisheries

No protected species should be affected by small pelagic fisheries.

5.2 Environmental indexes

A new project is starting from this year in order to investigate bottom-up processes and the environmental effects on sardines and anchovies.

5 Stock Assessment

The stock assessment relies only on the direct method with no analytical model being used.

6 Stock predictions

As no analytical assessment exists, no stock predictions are done.

7 Draft scientific advice

Generally for these last 4 to 5 years, we had been observing very low and depleted adult (age 1+) biomass, contrasting with the high recruitment. This may suggest an important external spawning biomass contribution to the GSA07 stock or a very high adult mortality or migration right after first reproduction. At the same time, complementary biological indices such as condition index, growth rate, and size at first maturity decreased both significantly and rapidly, more indications of a stock in a poor state trying to adapt by modifying its life-history traits. Also, it should be noted that the GSA07 system has been showing important changes in the structure of the main stocks of sardines and anchovies with an unusually high abundance of sprats, so that the total number of fish from these 3 species is very high suggesting possible carrying capacity limit. Finally, the fleet did not manage to capture any significant amounts of sardine in the last few years, and the commercial activity has almost stopped since the end of 2009.

This year, for the first time, we observed an increase both in the total biomass and in the adult biomass. This may be the first sign of a recovery in the stock, but it need to be confirmed both by biological parameters and abundance trends in the future years. Besides, recruitment level remains high as in the past 5 years. Yet, it should be noted that the length-based separation between adults and recruits has been modified this year (12 cm instead of 13 cm) due to the observed changes in growth patterns and length distribution of the population.

Because these are the first positive signs for the stock and because we have not yet observed any improvement in the biological parameters, we would recommend not to increase fishing effort (the fishing effort is already very low) to allow the stock to recover, by preventing additional sources of mortality to this still fragile stock.

Table 8.1: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
1993-2012		1993-2012	
	No fishing mortality		Virgin
X	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality	X	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table 8.2: Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
1993-2012		1993-2012	
[Range]		[Range]	
	Stable		Stable
	Increasing	X	Increasing
X	Decreasing*		Decreasing

*2012 exhibits a higher biomass that if confirmed in the following years could reverse the trend to a positive one.

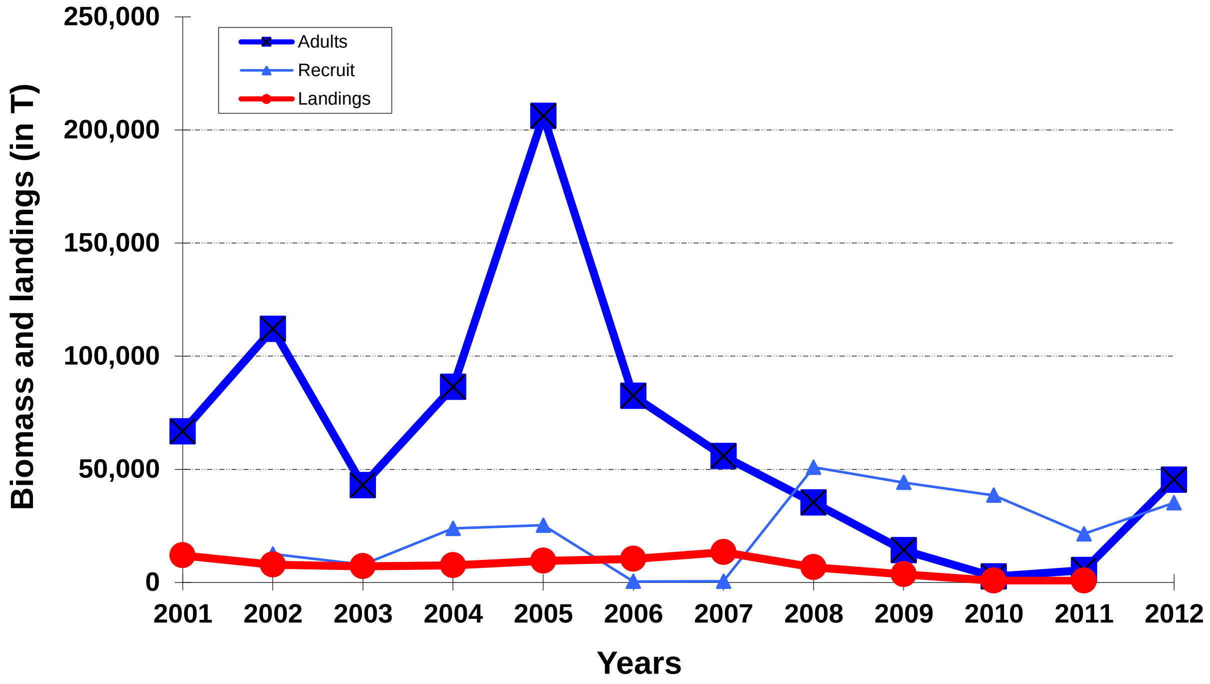


Figure 8.1: Adult and recruit biomass (in tons, blue lines) and landings (in tons, red line) of sardines in the Gulf of Lions from 1993 to 2012. The proportion of adults and recruits are calculated based on the estimated size at first maturity. This size has been re-evaluated in 2012 from 13cm to 12cm.

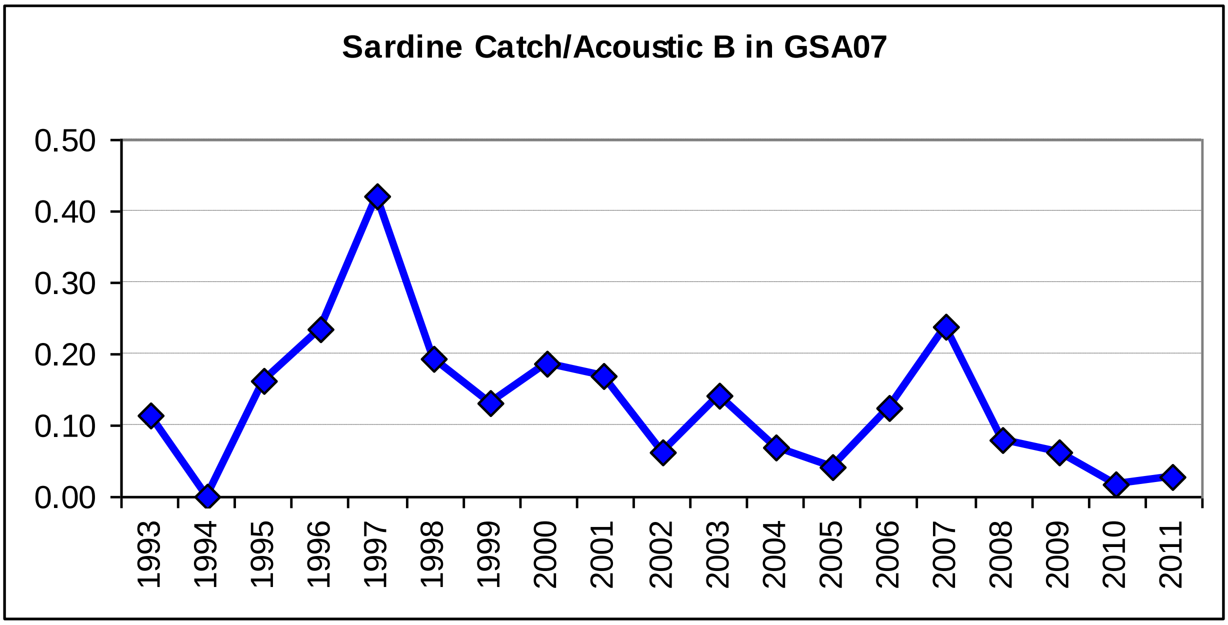


Figure 8.2: Proportion of sardine catches on the total sardine biomass estimated by acoustics from 1993 to 2011.

Stock Assessment Form

Anchovy in Gulf of Lion (GSA 07)

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Engraulis encrasicolus	Anchovy	35
1st Geographical sub-area:	2nd Geographical sub-area:	3rd Geographical sub-area:
GSA07 gulf of Lions		
1st Country	2nd Country	3rd Country
France		
Stock assessment method: (direct, indirect, combined, none)		
direct		
Authors:		
Jean Louis Bigot, Jean Hervé Bourdeix, David Roos, Claire Saraux		
Affiliation:		
IFREMER BP171 Av. Jean Monnet 34203 SETE CEDEX (France)		

2 Stock identification and biological information

2.1 Stock unit

The assessment covers the whole GSA07 area corresponding to the Gulf of Lions. However, we think that the Gulf of Lions do not correspond to a complete stock unit. Indeed, hydrological exchanges between the Gulf of Lions and the Catalan Sea for instance are well known, which should at least affect larval transport and then recruitment of juvenile anchovies in both areas. Similarly, part of the young recruited in the Gulf of Lions anchovy population may come from larval transport from spawners of the Ligurian Sea. Further, preliminary genetic analyses have shown no differences between Spanish and French stocks of anchovies in the North-Western Mediterranean Sea.

2.2 Growth and maturity

Table 2.1: Maximum size, size at first maturity and size at recruitment.

omatic magnitude measured (LH, LC, etc)*					Units*	
Sex	Fem	Mal	Both	Unsexed		
Maximum size observed	18.5	17	18.5		Reproduction season	Spring-Summer
Size at first maturity	9	9	9		Reproduction areas	Shelf and upper
Recruitment size	5	5	5		Nursery areas	Shelf and upper

*Maximum size observed corresponds to the maximum size ever observed in a PELMED campaign

*Size at first maturity was calculated based on samplings in July of the last few years.

Table 2.2: Growth and length weight model parameters

		Units	female	male	both	unsexed
			Sex			
Growth model	L_∞					19.1
	K					0.35
	t_0					-1.42
	Data source	Growth model parameters come from the litterature				
Length weight relationship	a					0.0042
	b					3.1231
	M (vector by length or age)					
	sex ratio (% females/total)					

Length-weight relationship parameters are derived from data collected in 2012 only.

3 Fisheries information

3.1 Description of the fleet

Table 3.1: Description of operational units in the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	FRA	07	E – Trawl (12-24 m)	03 - Trawls	31-Small gregarious pelagic	ANE
Operational Unit 2	FRA	07	H – Purse Seine (12-24 m)	02 – Seine Nets	31-Small gregarious pelagic	ANE

Table 3.2: Catch, bycatch, discards and effort by operational unit

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
FRA 07 E 03 31 -ANE	15	Tons	1593.6	Sardine	No discards	Spratus spratus	Nb boats
FRA 07 H 02 31 - ANE	3	Tons	15.6	Sardine	No discards		Nb boats
Total	18	Tons					

Pelagic-trawl

In 2011, Only 10 boats regularly caught anchovy

Purse-seine

In 2011, the three boats targeting anchovies fished only during 2, 3 and 5 months respectively.

3.2 Historical trends

Figure 3.1: Number of French anchovy catches (in tons, red line and right axis) and boats operating on small pelagics (green line, left axis) in the Gulf of Lions from 1999 to 2012.

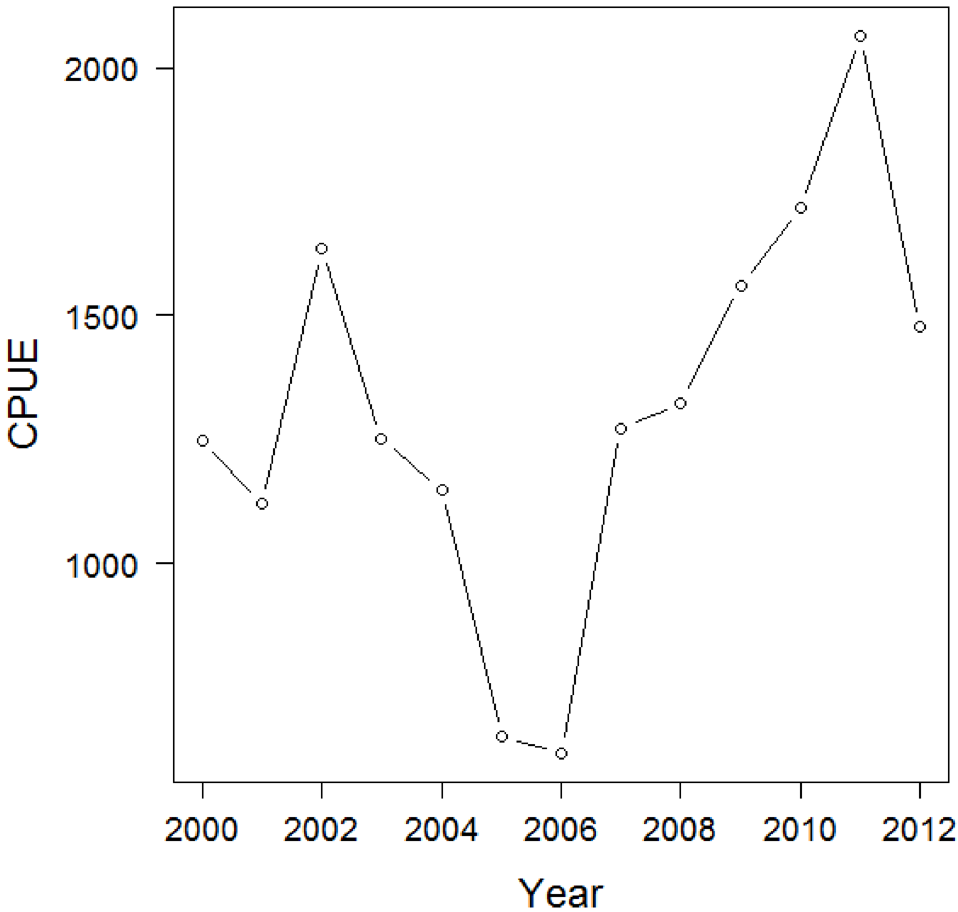


Figure 3.2: Catches per unit effort defined as the catches in tons divided by the cumulative number of fishing days from 2000 to 2012.

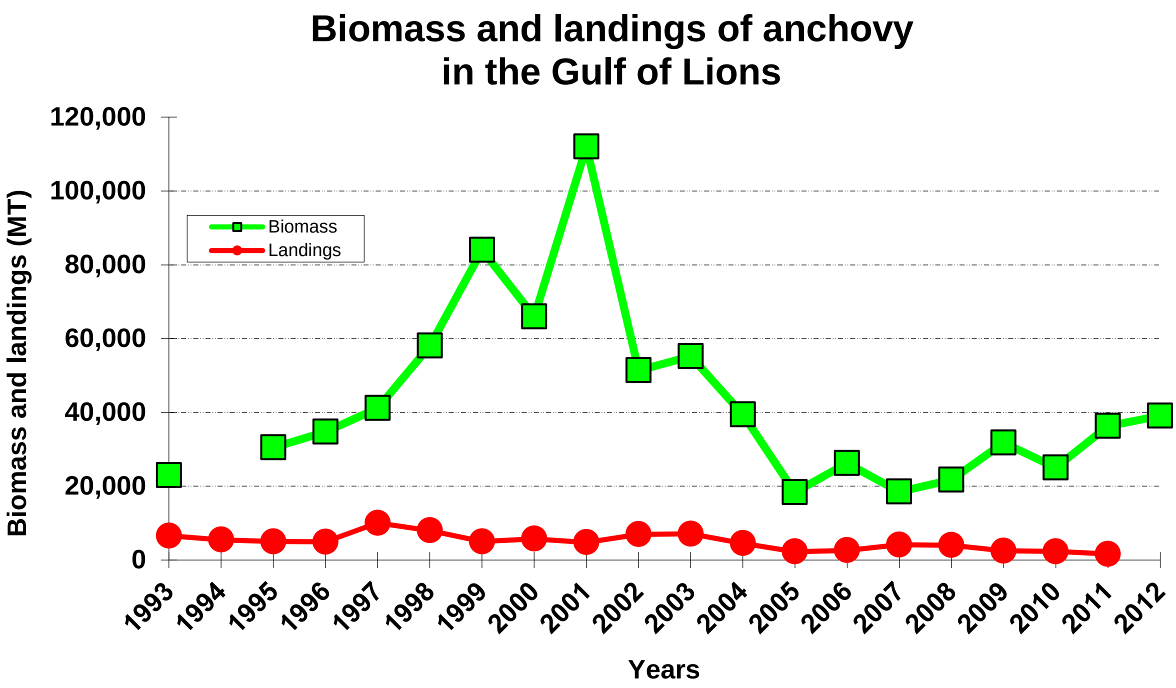


Figure 3.3: Biomass (in tons, green line) and landings (in tons, red line) of anchovies in the Gulf of Lions from 1993 to 2012.

3.3 Management regulations

- Exclusive licence for trawling, with a given number each year (both for small pelagics and demersals) - fully respected
- Limited engine power for trawlers to 318 kW or 430 hp - not respected
- Length of fishing trawlers inferior to 25 meters - fully respected
- Fishing effort limitations:
    - No fishing on Saturdays and Sundays, authorised hours trip: 3.00am to 8.00pm - fully respected
    - Trawling forbidden from coast to 3NM - not fully respected
    - Professional organisation regulations: Additional holidays: on average 40 days/year - fully respected

3.4 Reference points

Table 3.3: List of reference points

Criterion	Current value	Units	Reference Point	Trend	Comments
B					
SSB					
F					
Y					
CPUE					

4 Fisheries independent information

4.1 Direct acoustic method

4.1.1 Brief description of the chosen method and assumptions used

Sampling was performed along 9 parallel and regularly interspaced transects (inter-transect distance = 12 nautical miles, see map below). Acoustic data were obtained by means of echosounders (Simrad ER60) and recorded at constant speed of 8 $nm.h^{-1}$. The size of the elementary distance sampling unit (EDSU) was 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output (Simmons & MacLennan 2005). Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a 30 min-trawl at 4 $nm.h^{-1}$ in order to evaluate the proportion of each species (by randomly sampling and sorting of the catch before counting and weighing each individual species). While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminarily treated with Movies + software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts.

Table 4.1: Acoustic cruise information.

Date	27 June 2012 – 31 July 2012		
Cruise	PelMed 2012	**Cruise**	PELMED12
Target species	Anchovies-Sardines		
Sampling strategy	9 // transect spaced 12 Nm		
Sampling season	Summer		
Investigated depth range (m)	10-200m		
Echo-sounder	ER60 38 KHz for assessment 70, 120 and 200 used as complementary frequency		
Fish sampler	Pelagic trawl 4FF176 with 7 m of vertical opening 4PM159 with 16 m of vertical opening		
Cod –end mesh size as opening (mm)	9 mm of mesh side; 18 mm of mesh size		
ESDU (i.e. 1 nautical mile)	1 Nm		
TS (Target Strength)/species	- 71.2 for anchovy and sardine		
Software used in the post-processing	Movies+ and R scripts		

Samples (gear used)	Pelagic trawl
Biological data obtained	Length-Weight relationship, Age, Sex, Maturity (not yet assessed for 2012)
Age slicing method	Otolith
Maturity ogive used	

Table 4.2: Acoustic results, if available by age or length class

	Biomass in metric tons	**fish numbers**	**Nautical Area Scattering Coefficient**	**Indicator ...**	**Indicator ...**
Anchovies	39 061	5 142.302 million			
Sardines	80 537	9 370.835 million			
Sprats	70 263	14 649.016 million			

This corresponds to the abundance and biomass of the whole sampled area.

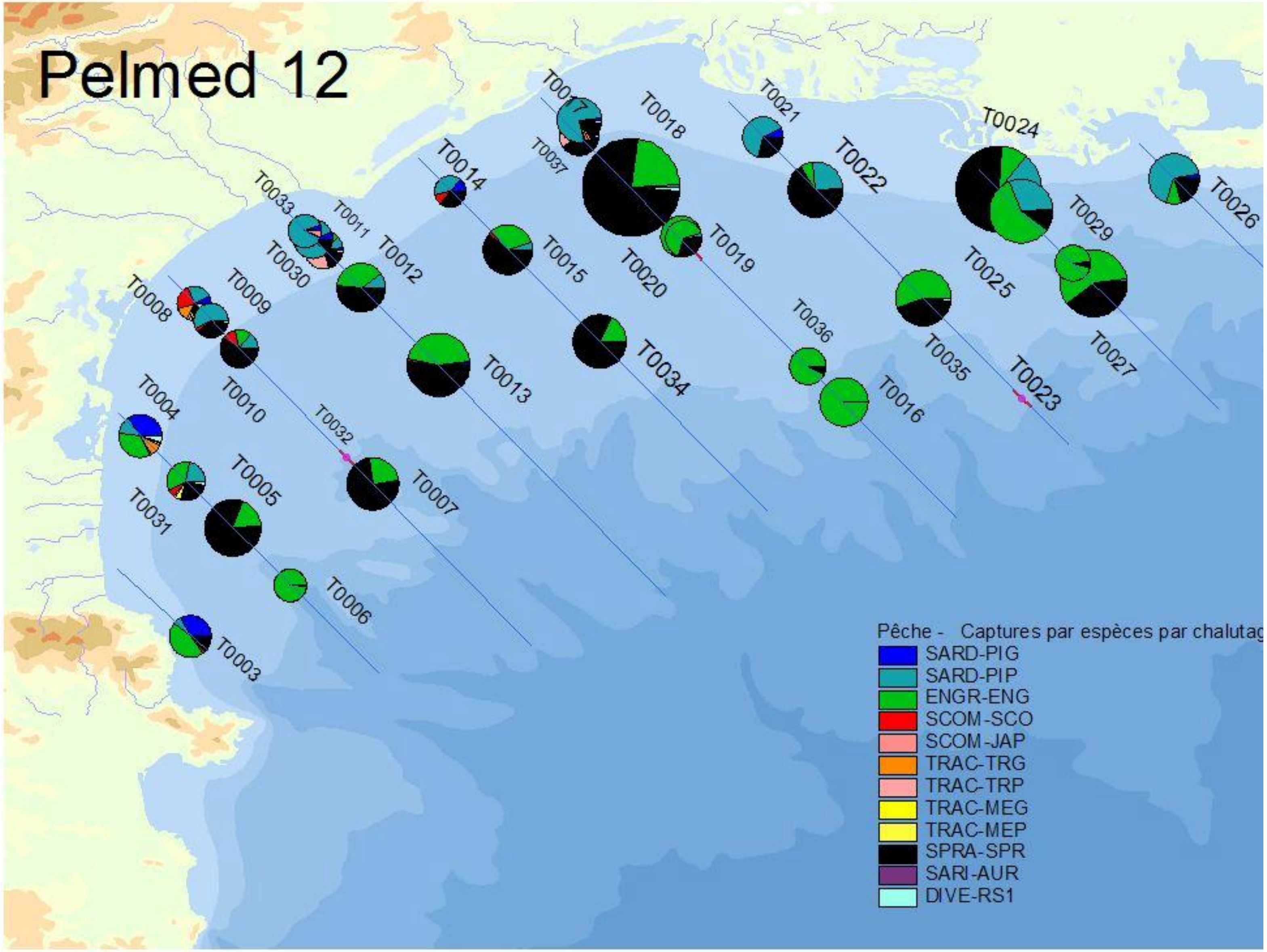


Figure 4.1: Map of the 2012 PELMED Campaign, survey performed in July 2012 to estimate small pelagic fish biomass in the Gulf of Lions. Lines represent the 9 parallel transects along which the acoustic survey is performed, while pies represent the trawls performed and the species distribution in the trawls. Anchovies are represented in green. Other major small pelagic species are also represented, in blue for sardines and black for sprats. The size of the pie is indicative of the total weight fished per trawl (on a logarithmic scale).

4.1.2 Spatial distribution of the resources

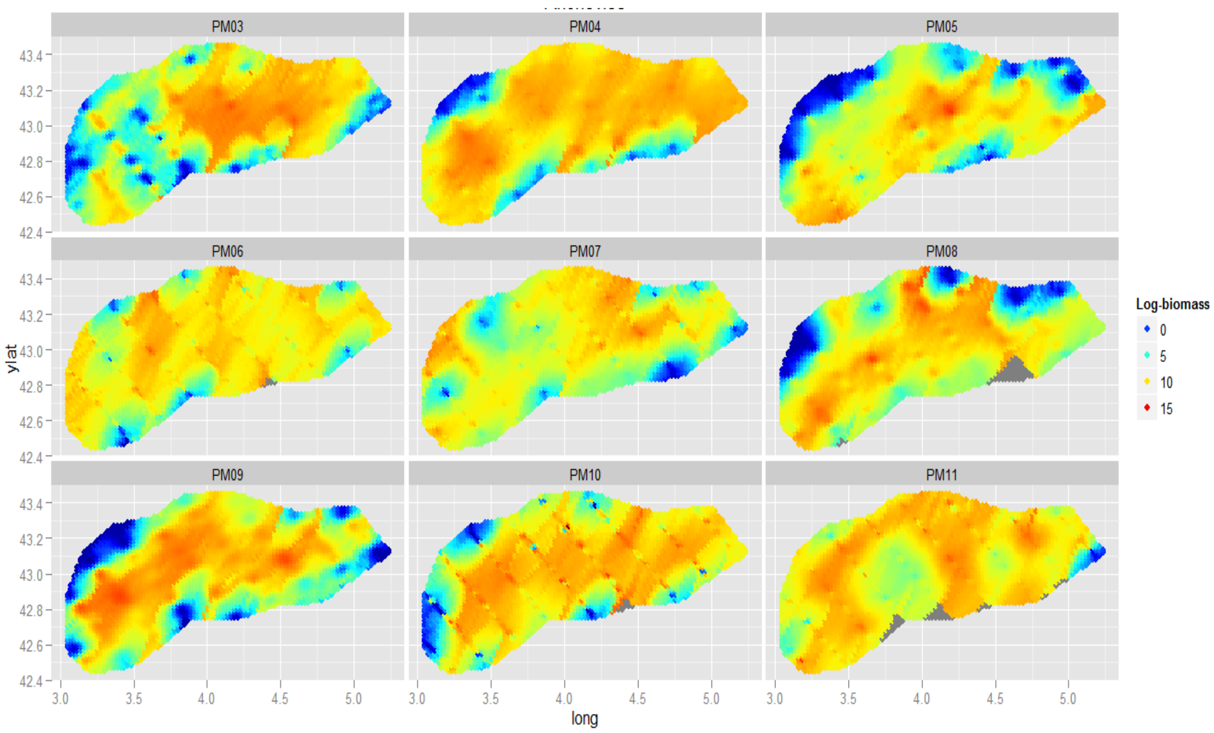


Fig. 4.2: Anchovy biomass distribution on a log-scale based on kriging methods for the 2003-2011 period.

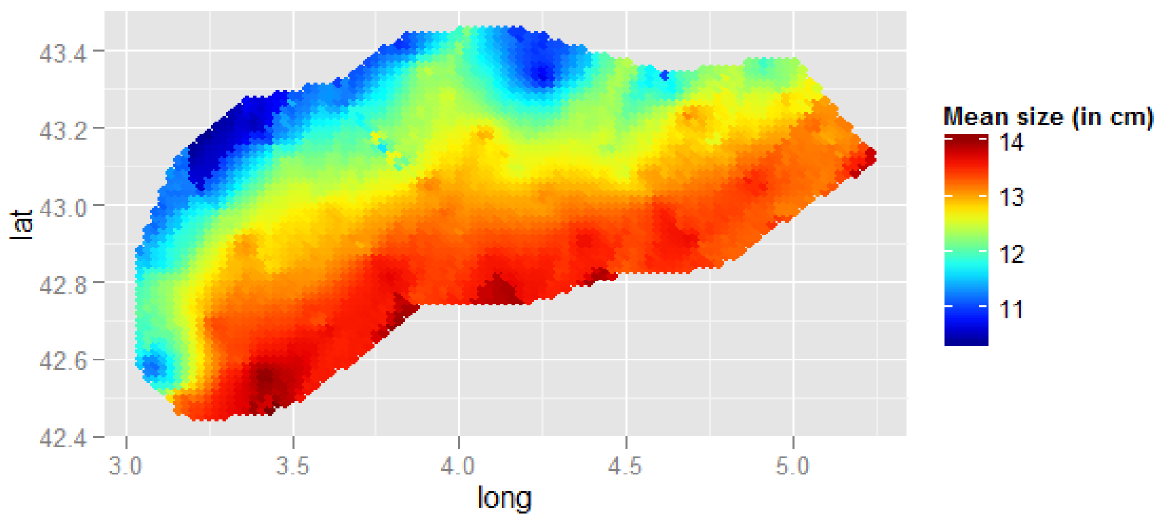


Fig. 4.3: Average mean size distribution based on kriging methods (average from 2003 to 2011).

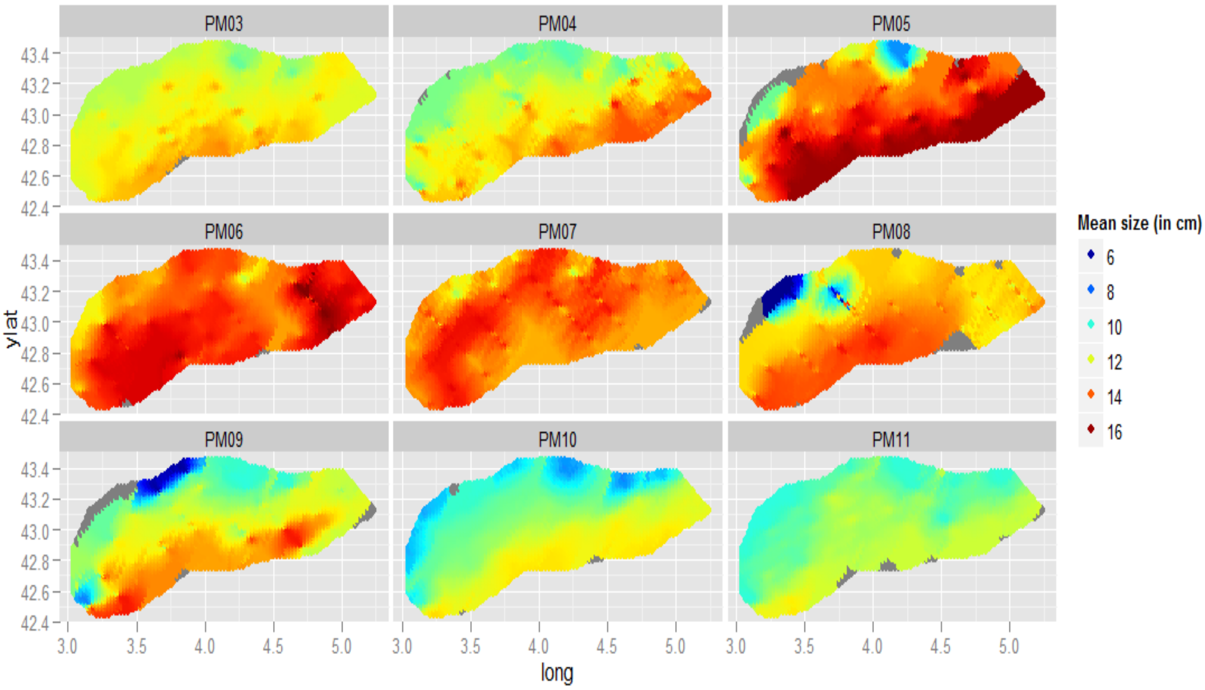


Fig. 4.4: Mean size distribution based on kriging methods for the 2003 – 2011 period.

4.1.3 Historical trends

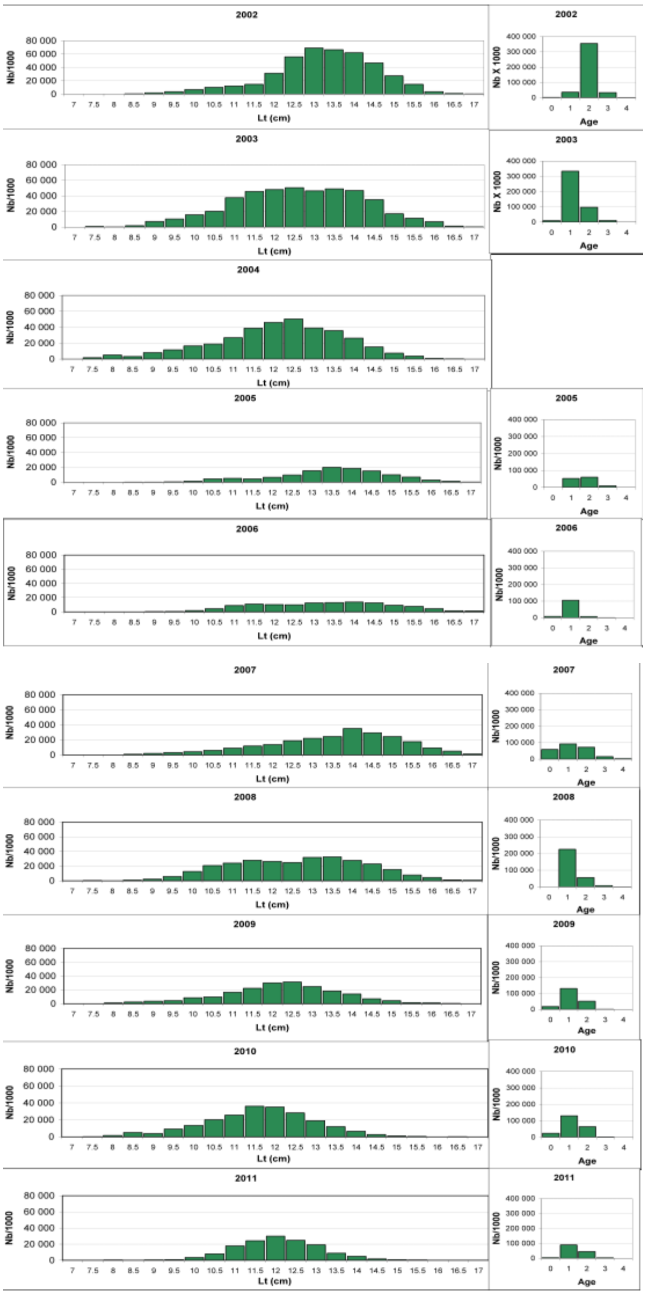


Figure 4.5: Size (on the right) and age (on the left) distribution of anchovies sampled during the PELMED summer campaigns from 2002 to 2010.

5 Ecological information

5.1 Protected species potentially affected by the fisheries

No protected species should be affected by small pelagic fisheries

5.2 Environmental indexes

A 3-year project is just starting to assess whether anchovies (and sardines) are controlled by bottom-up process or top-down ones in the Gulf of Lions. The effect of environmental conditions will first be investigated along with the condition and life-history traits of the individuals and in a second step we will try to define a first estimate of tuna impact on small pelagic fish.

6 Stock Assessment

The stock assessment relies only on the direct method with no analytical model being used.

7 Stock predictions

As no analytical assessment exists, no stock predictions are done.

8 Draft scientific advice

The total biomass of anchovies appears to have been quite stable (with even a slight increasing tendency) in GSA07 for the last 8 years. Yet, the stock remains quite unbalanced with a very-low commercial-sized anchovy abundance (age group of 1+). Further, the mean size and condition index observed in anchovies were appreciably below the values usually found for this stock. Therefore, we advise not to increase fishing effort to avoid increasing the pressure on the few adults. Finally, it should be noted that the GSA07 system has been showing important changes in the structure of the main stocks of sardines and anchovies with an unusually high abundance of sprats, so that the total number of fish from these 3 species is very high suggesting possible carrying capacity limit.

Table 8.1: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
1993-2012		1993-2012	
	No fishing mortality		Virgin
X	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality	X	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table 8.2: Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
1993-2012		1993-2012	
[Range]		[Range]	
x	Stable		Stable
	Increasing		Increasing
	Decreasing		Decreasing

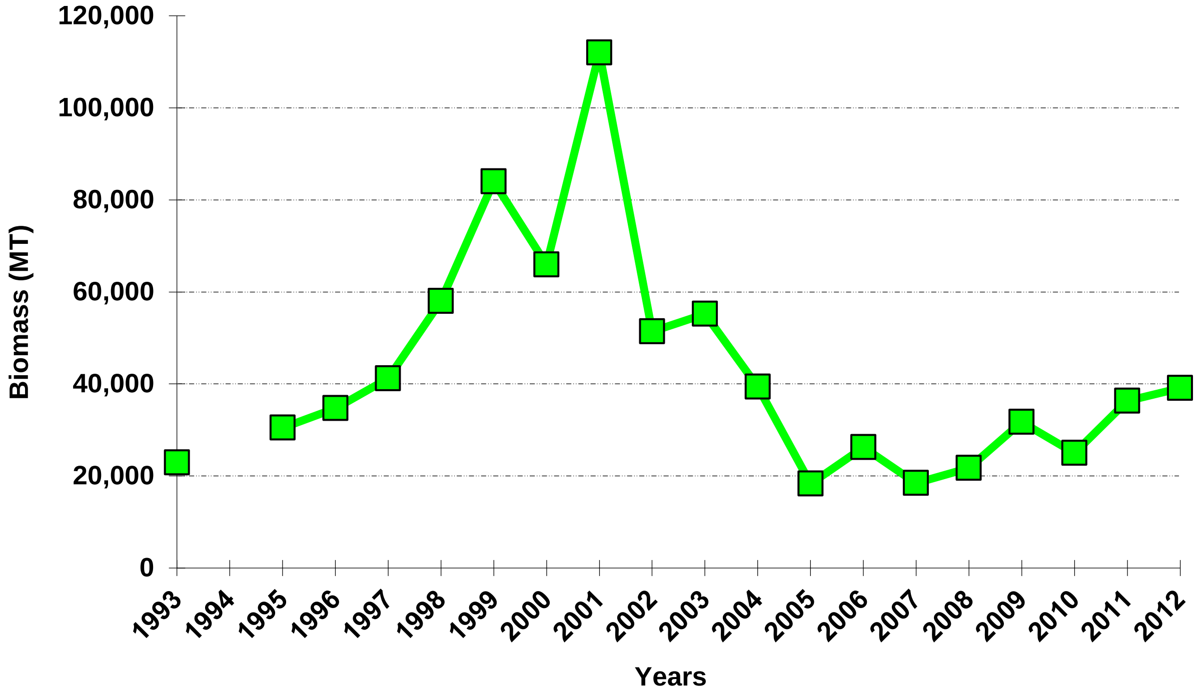


Figure 8.1: Anchovy biomass (in tons) in the Gulf of Lions from 1993 to 2012.

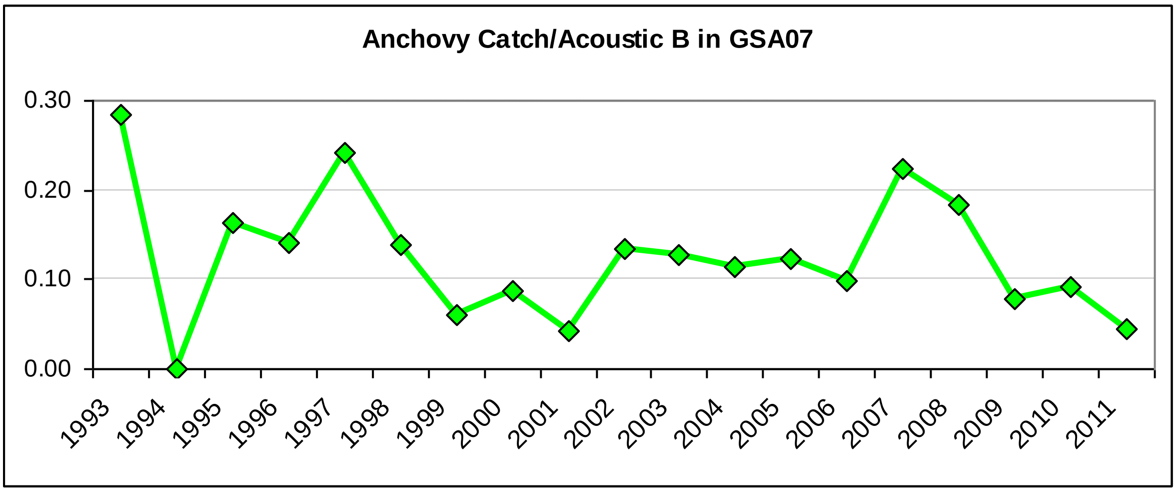


Figure 8.2: Proportion of anchovy catches on the total anchovy biomass estimated by acoustics from 1993 to 2011.

Stock Assessment Form

Sardine in GSA 16 (Southern Sicily)

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Sardina pilchardus	Sardine	
1st Geographical sub-area:	**2nd Geographical sub-area:**	**3rd Geographical sub-area:**
16		
1st Country	**2nd Country**	**3rd Country**
Italy		
Stock assessment method: (direct, indirect, combined, none)		
combined		
Authors:		
Patti B., Quinci E.M., Bonanno A., Basilone G., Mazzola S.		
Affiliation:		
CNR-IAMC		

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey
- Egg production survey
- Trawl survey

Indirect method (you can choose more than one):

- ICA
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify)

Combined method: you can choose both a direct and an indirect method and the name of the combined method (if it does exist)

2 Stock identification and biological information

2.1 Stock unit

This assessment of the sardine stock in GSA 16 is mainly based on information collected over the last decade on fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically on biomass estimates obtained by hydroacoustic surveys and catch-effort data from local small pelagic fisheries. The main distribution area of the sardine stock in GSA 16 is the narrow continental shelf area between Mazara del Vallo and the southernmost tip of Sicily, Cape Passero (Patti *et al.*, 2004).

2.2 Growth and maturity

Table 4.1.1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*			LT		Units*	cm
Sex	Fem	Mal	Both	Unsexed		
Maximum size observed				20.0	Reproduction season	Autumn - Winter
Size at first maturity	11.5	11.6	11.5		Reproduction areas	South Sicily
Recruitment size					Nursery areas	South Sicily

Table 4.1: Growth and length weight model parameters

			Sex			
		Units	female	male	both	unsexed
Growth model	L_∞	cm			21,41	
	K	y-1			0.40	
	t_0	year			-1.83	
	Data source	DCF 2007-2008				
Length weight relationship	a				0,0028	
	b				3.37	

M (vector by length or age)	0.77			Pauly (1980) relationship. Ref. Temp=13.5 °C	

sex ratio (% females/total)	

3 Fisheries information

3.1 Description of the fleet

In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port (accounting for about 2/3 of total landings): purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. In both OUs, anchovy represents the main target species due to the higher market price. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped.

Average sardine landings in Sciacca port over the period 1998-2011 were about 1,400 metric tons, with a general decreasing trend. The production dramatically decreased in 2010 (-70%), but increased again above the average in 2011. Fishing effort remained quite stable over the last decade. Sardine biomass, estimated by acoustic methods, ranged from a minimum of 6,000 tons in 2002 to a maximum of 39,000 tons in 2005. Current (2011) acoustic biomass is at intermediate level.
Landings data from Sciacca port were used for the stock assessment because of their importance (they accounts for about 2/3 of total landings; Patti et al., 2007) in GSA 16 and the availability of a longer time series (1998-2011) compared to the official data for the whole GSA 16 (2004-2011).

Table 4.1: Description of operational units in the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ITA	16	H - Purse Seine (12-24 metres)	01 - Surrounding Nets	31 - Small gregarious pelagic	PIL
Operational Unit 2	ITA	16	J - Pelagic Trawl (12-24 metres)	03 - Trawls	31 - Small gregarious pelagic	PIL
Operational Unit 3						
Operational Unit 4						
Operational Unit 5						

Table 4.11: Catch, bycatch, discards and effort by operational unit (Sciacca port only)

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
ITA 16 H 01 31 - PIL	17	Tons	680	anchovy	negligible	negligible	fishing day
ITA 16 J 03 31 - PIL	30	Tons	720	anchovy	negligible	negligible	fishing day
	* Dec 2006, census data		ave 1998-2011				
Total	47		1400				

Table 4.12: Catches as used in the assessment (aggregated data from the two operational units; values estimated for the whole GSA 16 extrapolated from Sciacca port fishery)

Classification	Catch (tn)
YEAR	
1998	2994
1999	1850
2000	3119
2001	2484
2002	2430
2003	1739
2004	2011
2005	1798
2006	1856
2007	1585
2008	2448
2009	1874
2010	565
2011	2665
Average 1998-2011	2101

3.2 Historical trends

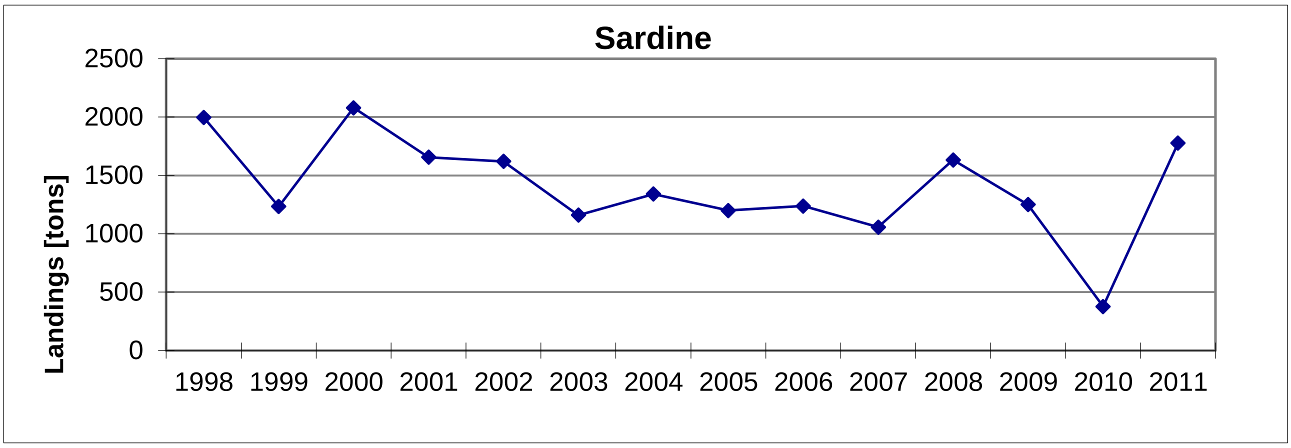


Fig. 3.1: Trends in sardine landings, years 1998-2011

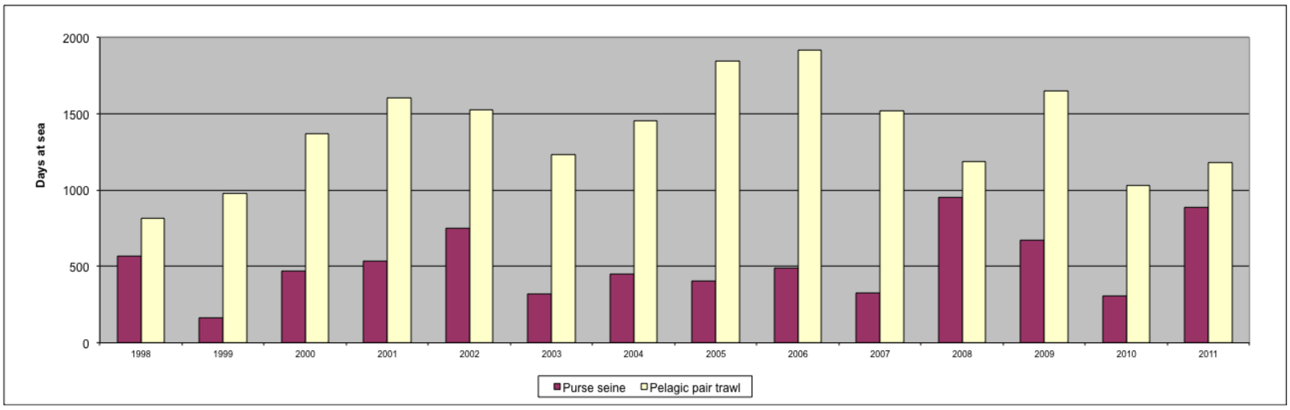


Fig. 3.2: Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2011

3.3 Management regulations

Fisheries practices are affected by EU regulations through the Common Fisheries Policy (CFP), based on the following principles: protection of resources; adjustment of (structure) facilities to the available resources; market organization and definition of relationships with other countries.

The main technical measures regulating fishing concern minimum landing size (11 cm for sardine), mesh regulations (20 mm for pelagic pair trawlers, 14 mm for purse seiners) and restrictions on the use of fishing gear. Towed fishing gears are not allowed in the coastal area in less than 50 m depth, or within a distance of 3 nautical miles from the coastline. A seasonal closure for trawling, generally during summer-autumn, has been established since 1993. In GSA 16, two operational units fishing for small pelagic fish are present, mainly based in Sciacca port: purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped.

3.4 Reference points

Table 3.4: List of reference points

Criterion	Current value	Units	Referenc e Point	Tren d	Comments
B					
SSB					
F					
Y					
CPUE					

4 Fisheries independent information

4.1 Acoustics

4.1.1 Brief description of the chosen method and assumptions used

Steps for biomass estimation

- Collection of acoustic and biological data during surveys at sea;
- Extraction of $NASC_{Fish}$ (Fishes Nautical Area Scattering Coefficient [$m^2/n.mi^2$]) by means of Echoview (Sonar Data) post-processing software;
- Link of NASC values to control catches;
- Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data;
- Production of ρ distribution maps for different fish species and size classes;
- Integration of density areas for biomass estimation.

Collection of acoustic and biological data

Since 1998 the IAMC-CNR has been collecting acoustic data for evaluating abundance and distribution pattern of small pelagic fish species (mainly anchovy and sardine) in the Strait of Sicily (GSA 16). The scientific echosounder Kongsberg Simrad EK500 was used for acquiring acoustic data until summer 2005; for the echosurvey in the period 2006-2011 the EK60 echosounder was used. In both cases the echosounder was equipped with three split beam transducers pulsing at 38, 120 and 200 kHz. During the period 1998-2008 acoustic data were collected continuously during day and night time; since the 2009 echosurvey acoustic data are collected during daytime, according to the MEDIAS protocol.

Before or after acoustic data collection a standard procedure for calibrating the three transducers was carried out by adopting the standard sphere method (Johannesson & Mitson, 1983).

Biological data were collected by a pelagic trawl net with the following characteristics: total length 78 m, horizontal mouth opening 13-15 m, vertical mouth opening 6-8 m, mesh size in the cod-end 10 mm. The net was equipped with two doors with weight 340 kg. During each trawl the monitoring system SIMRAD ITI equipped with trawl-eye and temp-depth sensors was adopted.

Extraction of $NASC_{Fish}$ by means of Echoview (Sonar Data) post-processing software

The evaluation of the $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) and the total NASC for each nautical mile of the survey track was performed by means of the SonarData Echoview software v3.50, taking into account the day and night collection periods.

Link of NASC values to control catches

For the echo trace classification the nearest haul method was applied, taking into account only representative fishing stations along transects.

Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data

For each trawl haul the frequency distribution of the *j*-th species (ν_j) and for the *k*-th length class (f_{jk}) are estimated as

$$\nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

where n_j is the total number of specimens of the *j*-th species, n_{jk} is the total number of specimens of the *k*-th length class in the *j*-th species, and *N* is the total number of specimens in the sample.

For each nautical mile the densities for each size class and for each fish species are estimated as

$$\rho_{jk} = \frac{NASC_{FISH} * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(number of fishes / n.mi}^2\text{)}$$

$$\rho_{jk} = \frac{NASC_{FISH} * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(t / n.mi}^2\text{)}$$

where W_{jk} is the total weight of the *k*-th length class in the *j*-th species, and σ_{jk} is the scattering cross section of the *k*-th length class in the *j*-th species. *σ_{jk} is given by*

$$\sigma_{sp_{jk}} = 4\pi * 10^{\frac{TS_{jk}}{10}}$$

where the target strenght (TS) is

$$TS_{jk} = a_j Log_{10}(L_k) + b_j$$

L_k is the length of the *k*-th length class while the a_j and b_j coefficient are linked to the fish species.

For anchovy, sardine and trachurus we adopted respectively the following relationships:

TS = 20 log L_k 76.1 [*dB*]
TS = 20 log L_k 70.51 [*dB*]
TS = 20 log L_k 72 [*dB*]

Integration of density areas for biomass estimation

The abundance of each species was estimated by integrating the density surfaces for each species.

Direct methods: acoustics

Table 4.1: Acoustic cruise information

Date	1998-2011		
Cruise	ANCHEVA series	**R/V**	Dallaporta
Target species	Anchovy and sardine		
Sampling strategy	Systematic, perperdicular to bathymetry Inter-transect distance: 5 nmi		
Sampling season	Summer		
Investigated depth range (m)	0-200m		
Echo-sounder	EK500, Ek-60		
Fish sampler	Pelagic trawl, vertical opening 10 m, horizontal opening 13 m. Trawling speed: 4 knots		
Cod –end mesh size as opening (mm)	18 mm		
ESDU (i.e. 1 nautical mile)	1		
TS (Target Strength)/species	TSdB = 20LogL – 70.51		
Software used in the post-processing	Echoview		
Biological data obtained	Length, weight, maturity, age		
Age slicing method			
Maturity ogive used			

Table 4.11: Acoustic results (July 2011)

	Biomass in metric tons	fish numbers	Nautical Area Scattering Coefficient (average value)	Indicator ...	Indicator ...
Sardine	14977		82.7		

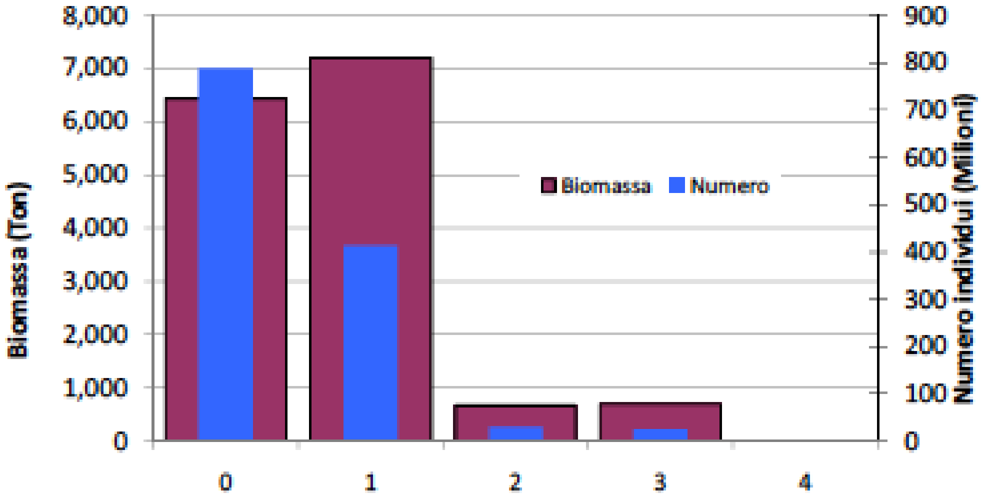


Fig. 4.1: Sardine distribution by age(years), 2011 survey

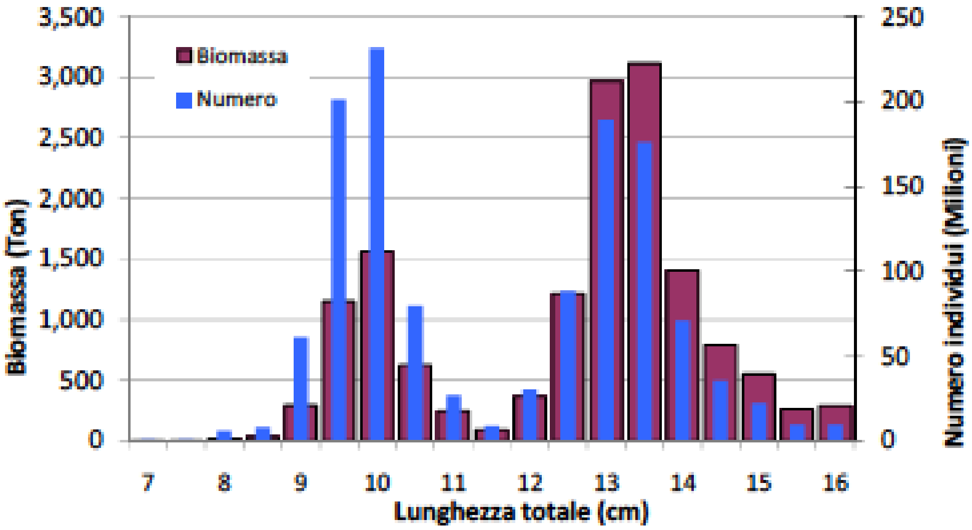


Fig. 4.2: Sardine distribution by length, 2011 survey

4.1.2 Spatial distribution of the resources

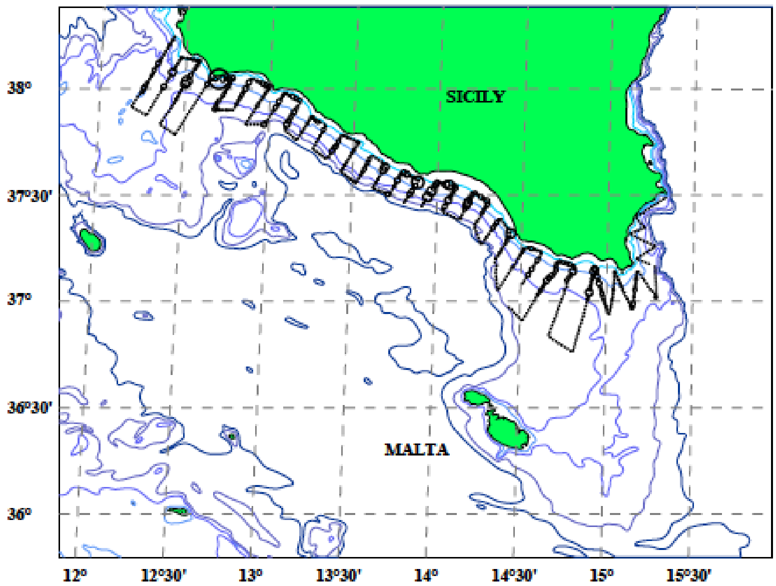


Fig. 4.3: Survey Ancheva 2009. Sardine density spatial distribution (t/nm²)

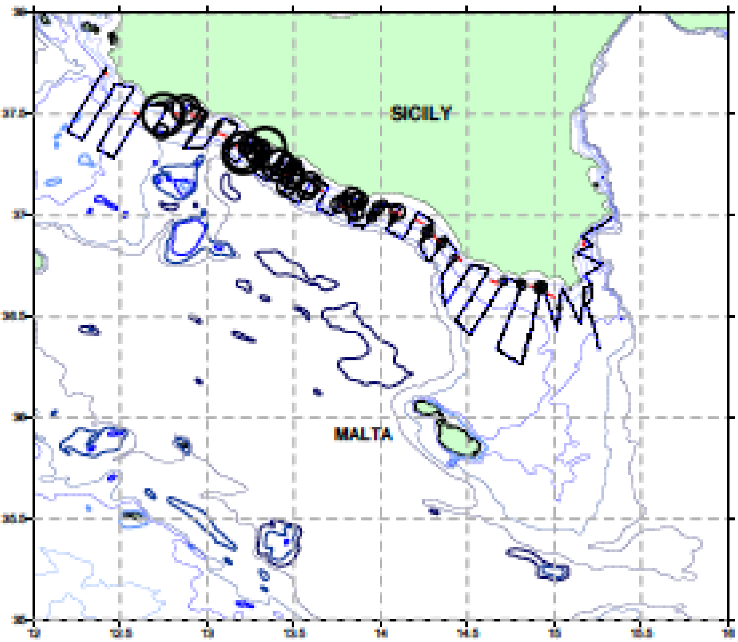


Fig. 4.4: Survey Ancheva 2010. Sardine density spatial distribution (t/nm²)

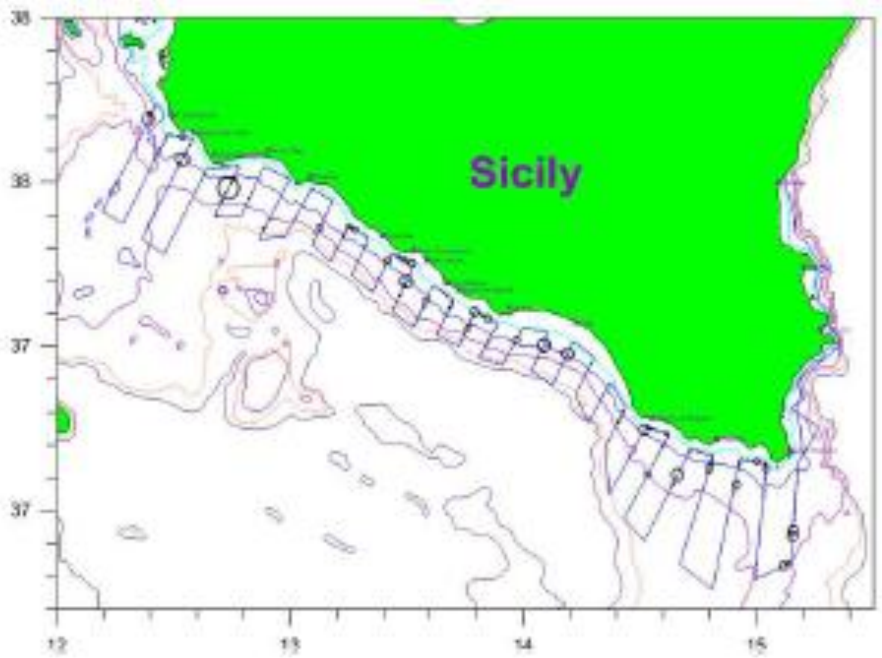


Fig. 4.5: Survey Ancheva 2011. Sardine density spatial distribution (t/nm²)

4.1.3 Historical trends

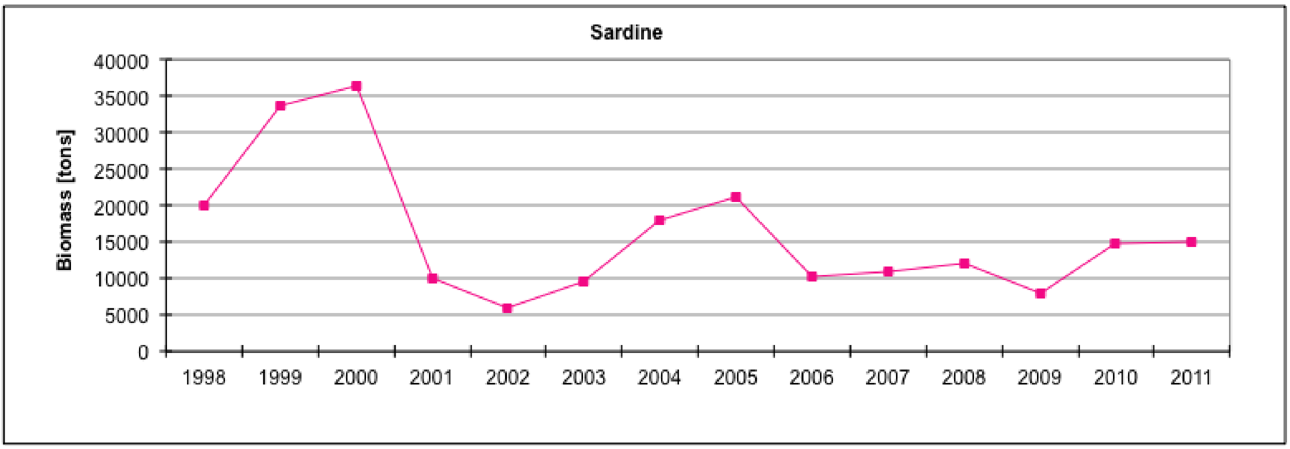


Fig. 4.6: Trends in sardine biomass, years 1998-2011.

Table 4.12: Estimated acoustic biomass values for sardine stock as used in the assessment

Classification	**Sardine biomass (tons)**
YEAR	
1998	20000
1999	33700
2000	36370
2001	10054
2002	6000
2003	9510
2004	17960
2005	21219
2006	10220
2007	11043
2008	12152
2009	8028
2010	14771
2011	14977
Average 1998-2011	16143

5 Ecological information

5.1 Protected species potentially affected by the fisheries

Dolphins' species: bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*).
Dolphins are reported to typically interact with fishing operations. However, by-catches occur only occasionally, as dolphins are usually able to prevent to be entangled.

5.2 Environmental indexes

The environmental index adopted and included in the modeling approach was the yearly average satellite-based (SeaWiFS and MODIS-Aqua) chlorophyll-a concentration estimate, calculated over the continental shelf of the study area.
Specifically, chl-a data NASA Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) and MODIS-Aqua projects, distributed as a Level 3 Standard Mapped Image product (Feldman and McClain, 2006), were used. Yearly composite images for the period 1998 to 2010 were downloaded from the http://oceancolor.gsfc.nasa.gov/cgi/l3 website in Hierarchical Data Format (HDF). These images have 2160 by 4320 pixels and a resolution of about 9 × 9 km^2.

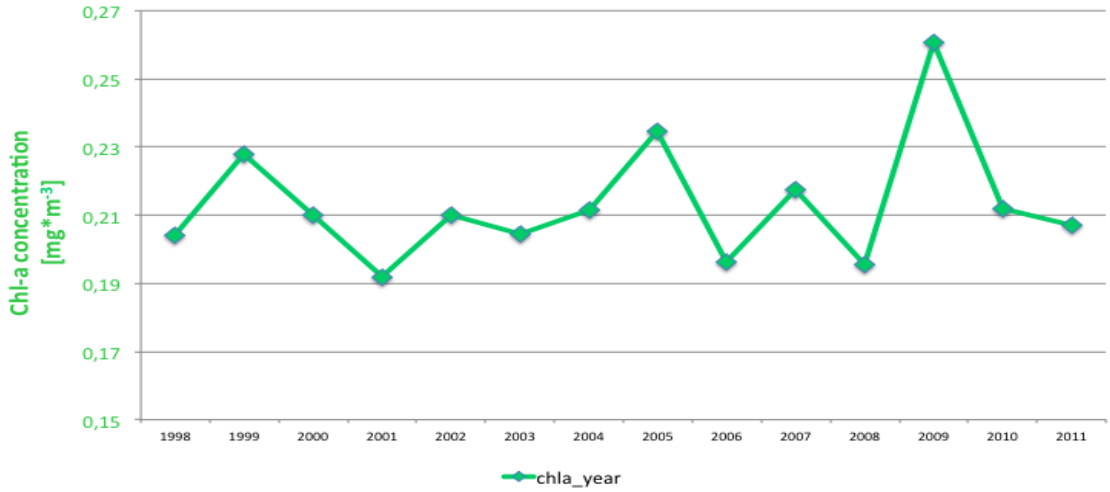


Figure 5.1: Mean annual chlorophyll concentration over the continental shelf of the study area from 1998 to 2011.

6 Stock Assessment

Two separate approaches were adopted:

- An empirical approach based on estimation of yearly and average (2008-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey);
- A modelling approach based on thefitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indeces, allowing for the optional incorporation of environmental indices, so that the *r* and/or *K* parameters of each year can be considered to depend on the corresponding value of the applied index.

6.1 Estimation of exploitation rates from harvest rates

6.1.1 Input data and model assumptions

The first approach for the evaluation of stock status, used in the present assessment, is based on the analysis of the harvest rates experienced in the available time series over the last years and on the related estimate of the current exploitation rate.

Landings data for GSA16 were obtained from DCF for the years 2006-2011 and from census information (on deck interviews) in Sciacca port (1998-2011). Acoustic data were used for fish biomass evaluations over the period 1998-2011. Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2008. Natural mortality was estimated following Pauly (1980) and by the Beverton & Holt's Invariants (BHI) method (Jensen, 1996). For the BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and k = 0.40.

The input data used for the stock was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2011. Available data were used to estimate yearly and average (2007-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey).

Actually, as long as this estimate of harvest rate can be considered as a proxy of F obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can also be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given. Sardine biomass estimates are based on acoustic surveys carried out during the summer and, as in general they would include the effect of the annual recruitment of the population, they are possibly higher than the average annual stock sizes. This in turn could determine in an underestimation of the harvest rates and of the corresponding exploitation rates.

6.1.2 Results

Annual harvest rates, as estimated by the ratio between total landings and stock sizes, indicated relatively low fishing mortality during the last decade.
The current (year 2011) harvest rate is 11.9% (DCF data were used for landings). The estimated average value over the years 2008-2011 is 13.7%.
The exploitation rate corresponding to F=0.137 is E=0.15, if M=0.77, estimated with Pauly (1980) empirical equation, is assumed, and E=0.16 if M=0.72, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. In relation to the above considerations on the possible overestimation of mean stock size in harvest rate calculation, it is worth noting that, even if the harvest rates were twice the estimated values, the exploitation rates would continue to be lower than the reference point (0.4) suggested by Patterson (1992). Thus, using the exploitation rate as a target reference point, the stock of sardine in GSA 16 would be considered as being sustainably exploited.

6.2 Non-equilibrium surplus production model

The sardine stock in the area was also assessed using a non-equilibrium surplus production model based on the Schaefer (logistic) population growth model.
The model was implemented in an MS Excel spreadsheet, modified from the spreadsheets distributed by FAO under the BioDyn package (P. Barros, pers. comm.). Details about the implementation of the applied logistic modelling approach can be found in a FAO report on the Assessment of Small Pelagic Fish off Northwest Africa (FAO, 2004).
The report is available at the web site http://www.fao.org/docrep/007/y5823b/y5823b00.htm.

6.2.1 Input data and model assumptions

The input data used for the adopted modelling approach was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2011. Specifically, the time series of estimated total yearly sardine landings for GSA 16 between 1998 and 2011 was used as input data for the model, together with the abundance indices from acoustic surveys from the same set of years.
Available data were used as input for the fitting of a non-equilibrium surplus production model to abundance indices, assuming an observation error model. The scientific surveys, mainly carried during early summer of each year, were considered to represent the stock abundance the same year including part of the recruitment. In addition an enviromental index, the satellite based estimate of yearly average chlorophyll-a concentration over the continental shelf off the southern sicilian coast, was used in the attempt of improving the performance of the model fitting, as expected because pelagic stocks are known to be significantly affected by environmental variability.
The model uses four basic parameters: Carring capacity (or Virgin Biomass) K, population intrinsic growth rate r, initial depletion BI/K (starting biomass relative to K) and catchability

q. Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the MSY, B_{MSY} and F_{MSY} reference points.
Derived reference points were also evaluated: B_{Cur}/B_{MSY}, indicating whether the estimated stock biomass, in any given year, is above or below the biomass producing the MSY, and F_{Cur}/FSY_{Cur} (the ratio between the fishing effort in the last year of the data series and the effort that would have produced the sustainable yield at the biomass levels estimated in the same year), indicating whether the estimated fishing mortality, in any given year, is above or below the fishing mortality producing the sustainable (in relation to natural production) yield in that year.
Values of F_{Cur}/FSY_{Cur} below 100% indicate that the catch currently taken is lower than the natural production of the stock, and thus that so stock biomass is expected to increase the following year, while values above 100% indicate a situation where fishing mortality exceeds the stock natural production, and thus where stock biomass will decline next year. For comparison purposes, also the series of F_{Cur}/F_{MSY} was evaluated and reported.

6.2.2 Results

The results of the second assessment approach, which is based on the implementation of a non-equilibrium logistic surplus production model, are consistent with the previous considerations about trends in harvest rates and in estimated exploitation rates.
The fluctuations in stock biomass cannot be explained solely by the observed fishing pattern. This was an expected result, as pelagic stocks are known to be significantly affected by environmental variability. The incorporation of an environmental index in the model, significantly improved the fitting of the model, allowing the stock to grow more or less than average depending on the state of the environment in each year.
Model performance was quite poor (R^2 = 0.35) if no environmental effect is incorporated in the model. The best fit with the inclusion of the selected environmental factor (R^2 = 0.76; Fig. 6.2.2-1) was obtained when assuming in the model formulation a flexible carrying capacity, which was found to be positively affected by chlorophyll-a concentration at sea (exponential effect).
In the current adopted formulation of the model, satellite-based data on chlorophyll concentration showed to have a positive effect on the yearly carrying capacity. The current (year 2011) fishing mortality is below the sustainable fishing mortality at current biomass levels (F_{Cur}/FSY_{Cur}=0.69) but slightly above F_{MSY} (F_{MSY}=0.16; F_{Cur}/F_{MSY}=1.05) (Table 6.2.2-1), and fishing mortality experienced high values during the considered period, sometimes above sustainability (F_{Cur}/FSY_{Cur}>1; Fig. 6.2.2-2). In addition abundance was low over the last decade (B/B_{MSY} < 50%; B_{MSY} = 32527; B_{Cur}/B_{MSY} = 0.48; Fig. 6.2.2-3). However, the average production of the last three years (1400 tons) is well below the estimated MSY (5307 tons).

Table 4.11: Reference points

MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
5307	32527	0.16	48%	69%	105%

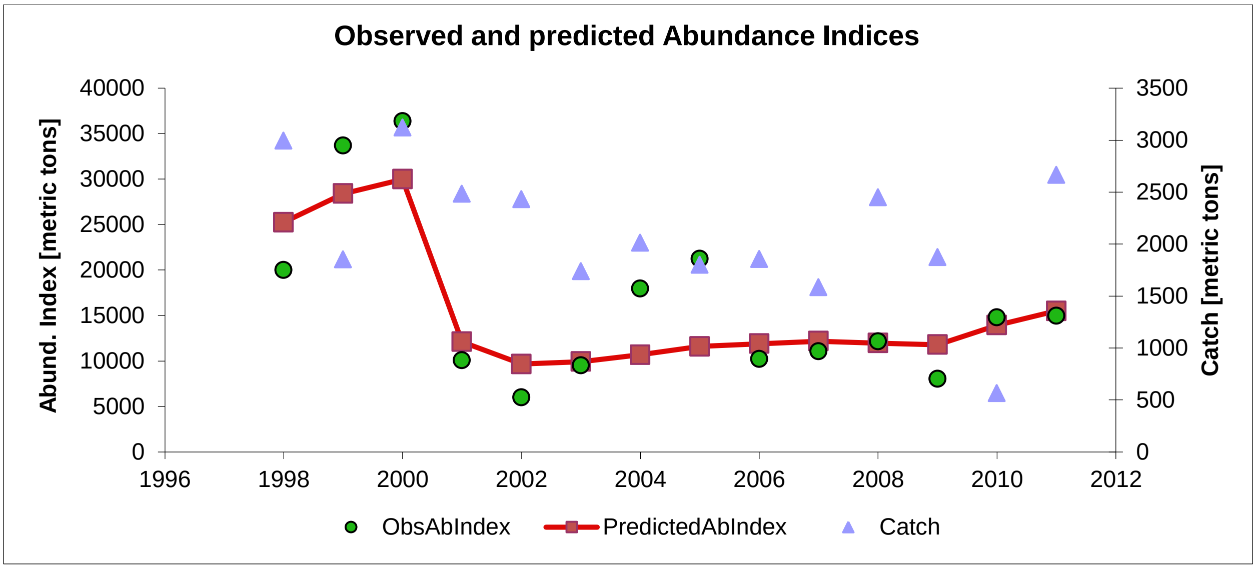


Figure 4.1.1: Best fit obtained with a flexible current capacity “K”, modulated by chl-a concentration at sea.

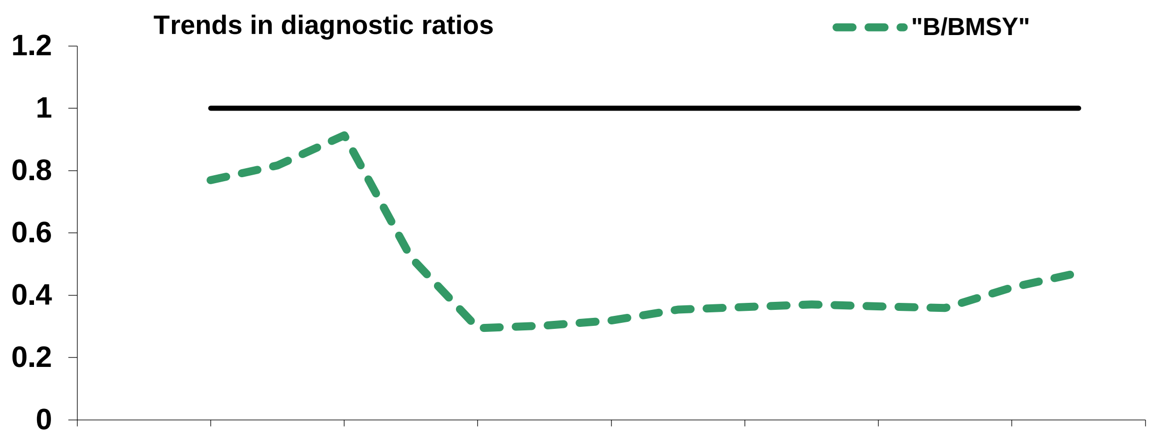


Figure 4.1: Trend in ratio between current biomass (B) and B_{MSY} over 1998-2011.

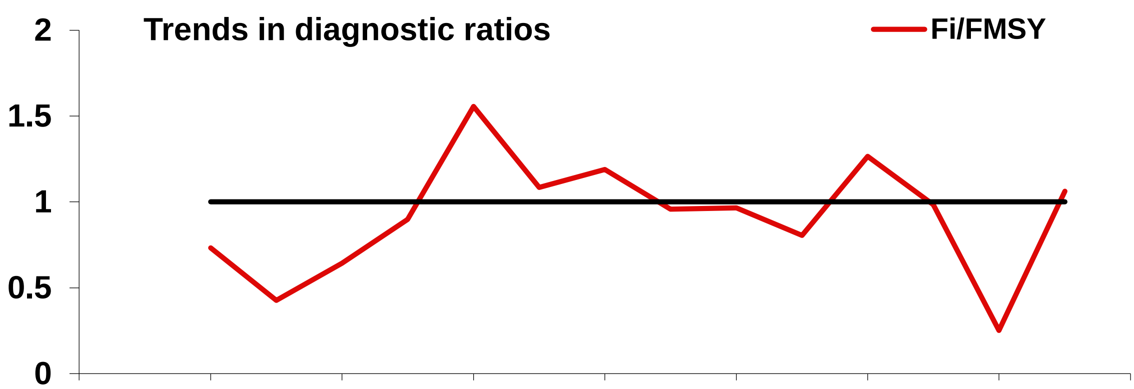


Figure 4.13: Trend in ratio between current fishing mortality (F) and F_{MSY} over 1998-2011.

6.3 *Robustness analysis*

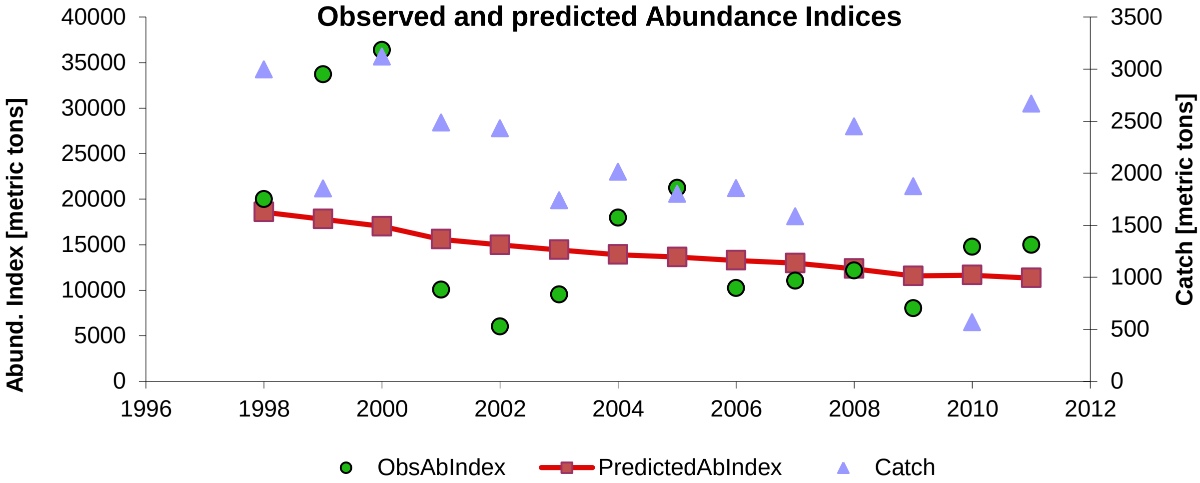


Figure 6.4: Best fit obtained without incorporating the environmental. Data 1998-2011.

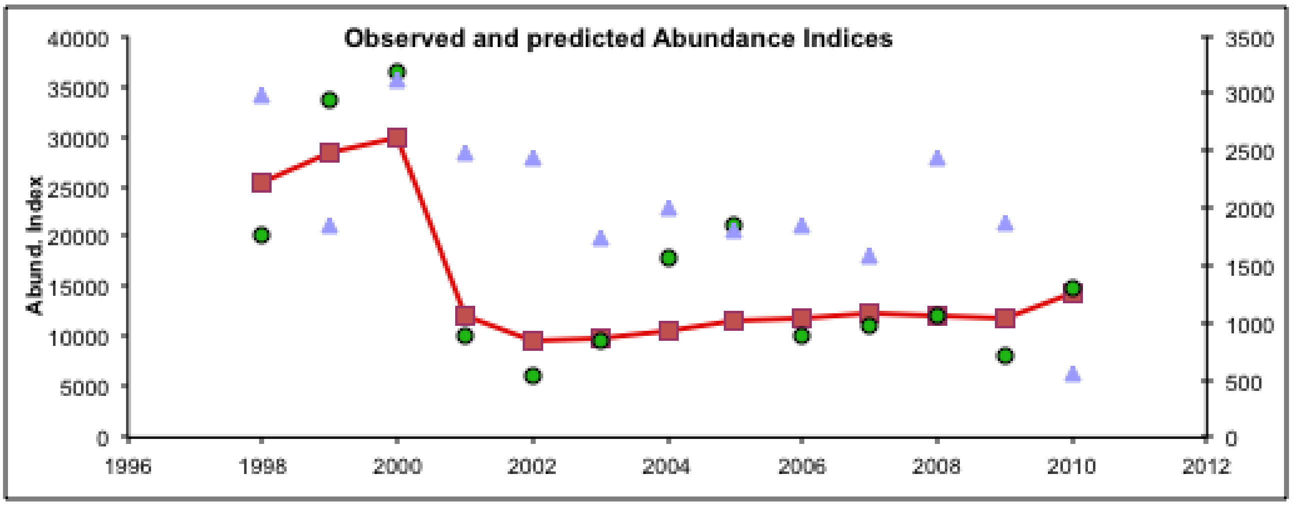


Figure 6.5: Results of the retrospective analysis run, obtained using data from 1998 to 2010. Best fit with a flexible current capacity "K", modulated by chl-a concentration at sea.

Table 4.12: Reference points for the retrospective analysis run and for the best fit obtained including updated data (2011) .

Year	MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
2010	5430	32476	0.17	48%	14%	22%
2011	5307	32527	0.16	48%	69%	105%

6.4 *Assessment quality*

The quality of input data is good and the obtained output is reasonable.
The current biomass level is estimated to be quite low compared to B_{MSY}, however it should be considered that the obtained results are always strictly linked to the choice of model formulation. In this case in particular, the carrying capacity has been considered to be variable depending on the environmental level of each year, and this will affect the estimated B_{MSY}.

Results of the retrospective analysis are satisfactory.

7 Stock predictions

No predictions were conduct during GFCM WG.

8 Draft scientific advice

8.1 Diagnosis of stock status

The present diagnosis of stock status is based on the evaluation of current exploitation pattern and biomass levels. The adopted reference points (RP) for fishing mortality were E=0.4 (Patterson) and FMSY, whereas for biomass level the WG proposed the use of both B_{MSY} and a new set of RP (B_{lim} and B_{pa}) as defined below.

Results of the adopted modelling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels (mostly due to recruitment success) and indicate that from year 2000 onward the stock status was well below the B_{MSY}.

In addition, the stock in 2010-2011 only partially recovered from the high decrease in biomass occurred in 2006 (-52% from July 2005 to June 2006), and this fact, along with the general decreasing trend in landings over the last decade, also suggests questioning about the sustainability of current levels of fishing effort.

A tentative B_{lim} was discussed and adopted by the WG as the lowest value observed in the last year of the series. Similarly, B_{pa} was established as B_{lim}*1.4.

Using the above reported RP, the current biomass estimate (14977 tons, 2011 value) is well below B_{MSY} (32527 tons), but above the adopted estimated B_{lim} (8028 tons) and also above B_{pa} (11239 tons) (Fig. 7-1).

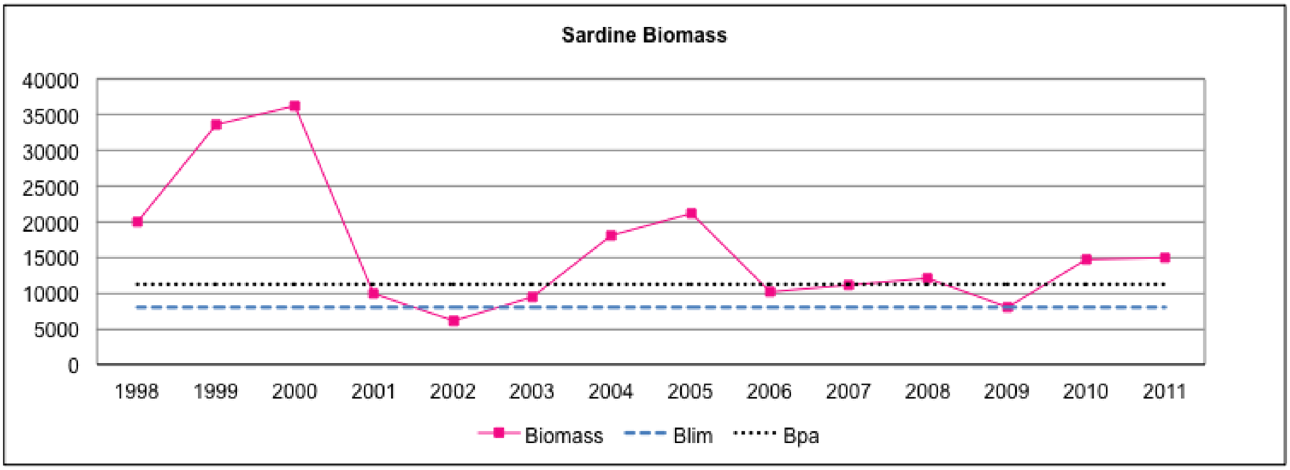


Fig. 8.1: Trends in sardine biomass (tons), years 1998-2011. Blim and Bpa are also indicated

Table 8.1: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
1998-2011		1998-2011	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
X	Sustainable Fishing Mortality	**X**	Intermediate abundance

	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table 8.2: Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
1998-2011		N.A.	
6000-36370 tons		[Range]	
	Stable		Stable
	Increasing		Increasing
X	Decreasing		Decreasing

8.2 Advices and recommendations

Given that the stock biomass over the last years appears to be in a stable low abundance phase respect to B_{MSY} and considering the fishing mortality pattern observed throughout the time series, fishing effort should not be allowed to increase and consistent catches should be determined. However, as the small pelagic fishery is generally multispecies, any management of fishing effort targeting the sardine stock would also have effects on anchovy. Local small pelagic fishery appears to be able to adapt at resource availability and market constraints, targeting the fishing effort mainly on anchovy. But due to the generally low biomass levels experienced by the anchovy stock over the last years (see related assessment), measures should be taken to prevent a possible further shift of effort back from anchovy to sardine.

8.3 Discussion:

The present assessment, based on the analysis of the abundance and fishing mortality levels observed in the available time series, implied the tentative precautionary evaluation of sustainable levels for current exploitation rates and for current biomass, also taking into the relative low (even stable) abundance phase together with a signal of increasing in the last years of the series.

9 References

Jensen, A.L. (1996). Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can. J. Fish. Aquat. Sci., 53: 820-822.

Patterson, K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. Review of Fish Biology and Fisheries, 2: 321-338.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer, 39 (3): 175-192.

Stock Assessment Form

Anchovy in GSA 16 (Southern Sicily)

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Engraulis encrasicolus	Anchovy	
1st Geographical sub-area:	2nd Geographical sub-area:	3rd Geographical sub-area:
16		
1st Country	2nd Country	3rd Country
Italy		
Stock assessment method: (direct, indirect, combined, none)		
combined		
Authors:		
Patti B., Quinci E.M., Bonanno A., Basilone G., Mazzola S.		
Affiliation:		
CNR-IAMC		

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey
- Egg production survey
- Trawl survey

Indirect method (you can choose more than one):

- ICA
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify)

Combined method: you can choose both a direct and an indirect method and the name of the combined method (if it does exist)

2 Stock identification and biological information

2.1 Stock unit

This assessment of the anchovy stock in GSA 16 is mainly based on information collected over the last decade on the fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically using biomass estimates obtained by hydro-acoustic surveys and catch/effort data from local small pelagic fisheries. The main distribution area of the anchovy stock in GSA 16 is the narrow continental shelf area between Mazara del Vallo and the southernmost tip of Sicily, Cape Passero (Patti *et al.*, 2004). Daily Egg Production Method (DEPM) surveys were also carried out starting from 1998, giving also information on spawning areas distribution.

2.2 Growth and maturity

Table 4.11: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*			LT		**Units***	cm
Sex	**Fem**	**Mal**	**Both**	**Unsexed**		
Maximum size observed			18		**Reproduction season**	Spring-Summer
Size at first maturity			11.2		**Reproduction areas**	South Sicilian Shelf
Recruitment size			9		**Nursery areas**	Cape Passero area

Table 4.1: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**both**	**unsexed**
Growth model	**L_∞**	cm			19.83	
	K	y-1			0.31	
	t_0	year			-1.95	
	Data source	DCF 2007-2009				
Length weight relationship	**a**					
	b					

M (vector by length or age)	0.66			Pauly (1980) relationship. Ref. Temp=13.5 °C	

sex ratio (% females/total; 2010 data)	55%

3 Fisheries information

3.1 Description of the fleet

In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port: purse seiners (lampara vessels, locally known as “Ciancioli”) and midwaters pair trawlers (“Volanti a coppia”). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. In both OUs, anchovy represents the main target species due to the higher market price. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped. Average anchovy landings in Sciacca port over the period 1998-2011 were about 2,000 metric tons, with large interannual fluctuations. Fishing effort remained quite stable over the last decade. Anchovy biomass, estimated by acoustic methods, ranged from a minimum of 3,100 tons in 2008 to a maximum of 23,000 tons in 2001. Current (2011) acoustic biomass estimate is below the average over the considered period (5,070 vs. 11,105).

Landings data from Sciacca port were used for the stock assessment because of their importance (they accounts for about 2/3 of total landings; Patti et al., 2007) in GSA 16 and the availability of a longer time series (1998-2011) compared to the official data for the whole GSA 16 (2004-2011).

Table 4.1: Description of operational units in the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ITA	16	H - Purse Seine (12-24 metres)	01 - Surrounding Nets	31 - Small gregarious pelagic	ANE
Operational Unit 2	ITA	16	J - Pelagic Trawl (12-24 metres)	03 - Trawls	31 - Small gregarious pelagic	ANE
Operational Unit 3						
Operational Unit 4						
Operational Unit 5						

Table 4.11: Catch, bycatch, discards and effort by operational unit (Sciacca port only)

Operational Units*	Fleet (n° of boats) *	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
ITA 16 H 01 31 - ANE	17	Tons	824	sardine	negligible	negligible	fishing day
ITA 16 J 03 31 - ANE	30	Tons	1243	sardine	negligible	negligible	fishing day
	* Dec 2006, census data		ave 1998-2011				
Total	47		2067				

Table 4.12: Catches as used in the assessment (aggregated data from the two operational units; values estimated for the whole GSA 16 extrapolated from Sciacca port fishery)

Classification YEAR	Catch (tn)
1998	781
1999	2043
2000	190
2001	1627
2002	3467
2003	2218
2004	1554
2005	2390
2006	4262
2007	4812
2008	1062
2009	4302
2010	5124
2011	4374
Average 1998-2011	3100

3.2 Historical trends

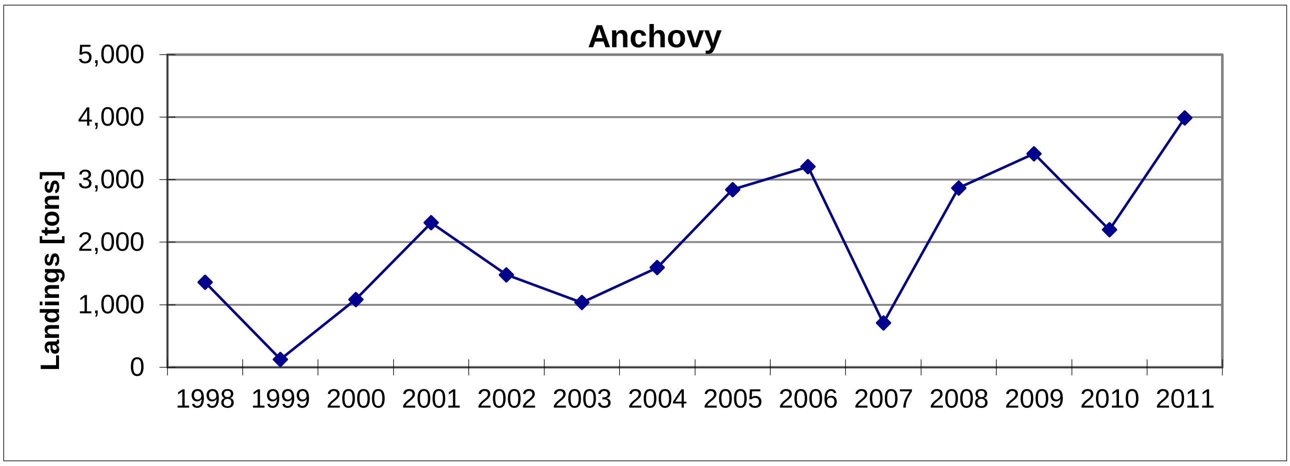


Fig. 3.1: Trends in anchovy landings, years 1998-2011

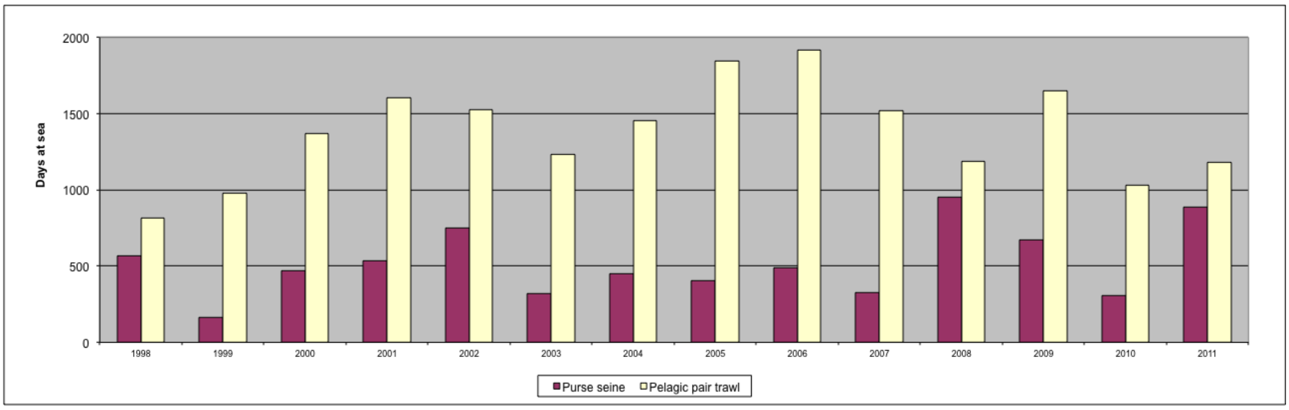


Fig. 3.2: Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2011

3.3 Management regulations

Fisheries practices are affected by EU regulations through the Common Fisheries Policy (CFP), based on the following principles: protection of resources; adjustment of (structure) facilities to the available resources; market organization and definition of relationships with other countries.

The main technical measures regulating fishing concern minimum landing size (9 cm for anchovy), mesh regulations (20 mm for pelagic pair trawlers, 14 mm for purse seiners) and restrictions on the use of fishing gear. Towed fishing gears are not allowed in the coastal area in less than 50 m depth, or within a distance of 3 nautical miles from the coastline. A seasonal closure for trawling, generally during summer-autumn, has been established since 1993. In GSA 16, two operational units fishing for small pelagic fish are present, mainly based in Sciacca port: purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped.

3.4 Reference points

Table 3.1: List of reference points

Criterion	Current value	Units	Referenc e Point	Tren d	Comments
B					
SSB					
F					
Y					
CPUE					

4 Fisheries independent information

4.1 Acoustics

4.1.1 Brief description of the chosen method and assumptions used

Steps for biomass estimation

- Collection of acoustic and biological data during surveys at sea;
- Extraction of $NASC_{Fish}$ (Fishes Nautical Area Scattering Coefficient [$m^2/n.mi^2$]) by means of Echoview (Sonar Data) post-processing software;
- Link of NASC values to control catches;
- Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data;
- Production of ρ distribution maps for different fish species and size classes;
- Integration of density areas for biomass estimation.

Collection of acoustic and biological data

Since 1998 the IAMC-CNR has been collecting acoustic data for evaluating abundance and distribution pattern of small pelagic fish species (mainly anchovy and sardine) in the Strait of Sicily (GSA 16). The scientific echosounder Kongsberg Simrad EK500 was used for acquiring acoustic data until summer 2005; for the echosurvey in the period 2006-2011 the EK60 echosounder was used. In both cases the echosounder was equipped with three split beam transducers pulsing at 38, 120 and 200 kHz. During the period 1998-2008 acoustic data were collected continuously during day and night time; since the 2009 echosurvey acoustic data are collected during daytime, according to the MEDIAS protocol.

Before or after acoustic data collection a standard procedure for calibrating the three transducers was carried out by adopting the standard sphere method (Johannesson & Mitson, 1983).

Biological data were collected by a pelagic trawl net with the following characteristics: total length 78 m, horizontal mouth opening 13-15 m, vertical mouth opening 6-8 m, mesh size in the cod-end 10 mm. The net was equipped with two doors with weight 340 kg. During each trawl the monitoring system SIMRAD ITI equipped with trawl-eye and temp-depth sensors was adopted.

Extraction of $NASC_{Fish}$ by means of Echoview (Sonar Data) post-processing software

The evaluation of the $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) and the total NASC for each nautical mile of the survey track was performed by means of the SonarData Echoview software v3.50, taking into account the day and night collection periods.

Link of NASC values to control catches

For the echo trace classification the nearest haul method was applied, taking into account only representative fishing stations along transects.

Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data

For each trawl haul the frequency distribution of the *j*-th species (ν_j) and for the *k*-th length class (f_{jk}) are estimated as

$$\nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

where n_j is the total number of specimens of the *j*-th species, n_{jk} is the total number of specimens of the *k*-th length class in the *j*-th species, and *N* is the total number of specimens in the sample.

For each nautical mile the densities for each size class and for each fish species are estimated as

$$\rho_{jk} = \frac{NASC_{FISH} * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(number of fishes / n.mi2)}$$

$$\rho_{jk} = \frac{NASC_{FISH} * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(t / n.mi2)}$$

where W_{jk} is the total weight of the *k*-th length class in the *j*-th species, and σ_{jk} is the scattering cross section of the *k*-th length class in the *j*-th species. σ_{jk} *is given by*

$$\sigma_{spjk} = 4\pi * 10^{\frac{TS_{jk}}{10}}$$

where the target strenght (TS) is

$$TS_{jk} = a_j Log_{10}(L_k) + b_j$$

L_k is the length of the *k*-th length class while the a_j and b_j coefficient are linked to the fish species.

For anchovy, sardine and trachurus we adopted respectively the following relationships:

TS = 20 log L_k 76.1 [dB]

TS = 20 log L_k 70.51 [dB]

TS = 20 log L_k 72 [dB]

Integration of density areas for biomass estimation

The abundance of each species was estimated by integrating the density surfaces for each species.

Direct methods: acoustics

Table 4.1: Acoustic cruise information

Date	1998-2011		
Cruise	ANCHEVA series	**R/V**	Dallaporta
Target species	Anchovy and sardine		
Sampling strategy	Systematic, perperdicular to bathymetry Inter-transect distance: 5 nmi		
Sampling season	Summer		
Investigated depth range (m)	0-200 m		
Echo-sounder	EK500, Ek-60		
Fish sampler	Pelagic trawl, vertical opening 10 m, horizontal opening 13 m. Trawling speed: 4 knots		
Cod –end mesh size as opening (mm)	18 mm		
ESDU (i.e. 1 nautical mile)	1		
TS (Target Strength)/species	TSdB = 20LogL – 75.10		
Software used in the post-processing	Echoview		
Biological data obtained	Length, weight, maturity, age		
Age slicing method			
Maturity ogive used			

Table 4.2: Acoustic results (July 2011).

	Biomass in metric tons	**fish numbers**	**Nautical Area Scattering Coefficient (average value)**	**Indicator ...**	**Indicator ...**
Anchovy	5070		17.0		

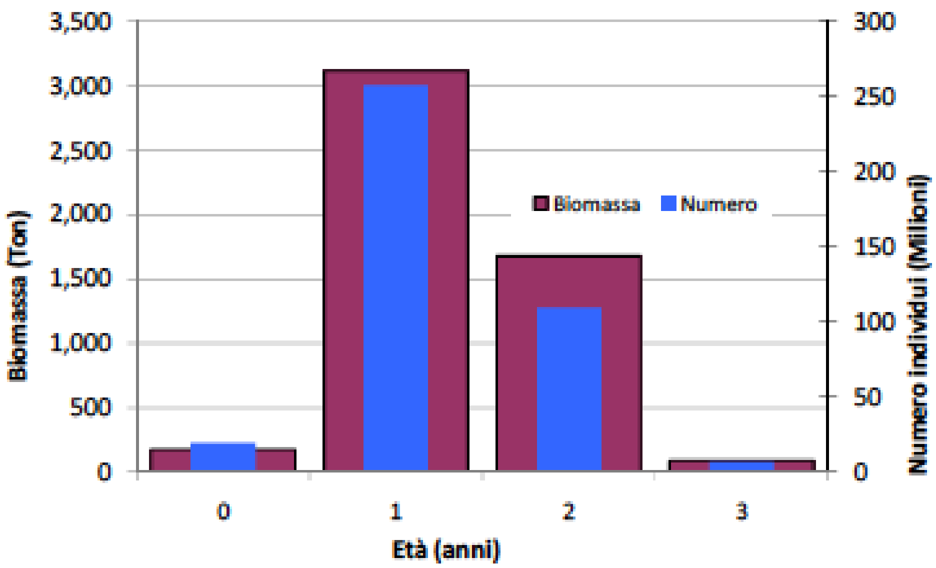


Fig. 4.1: Anchovy distribution by age (years), 2011 survey

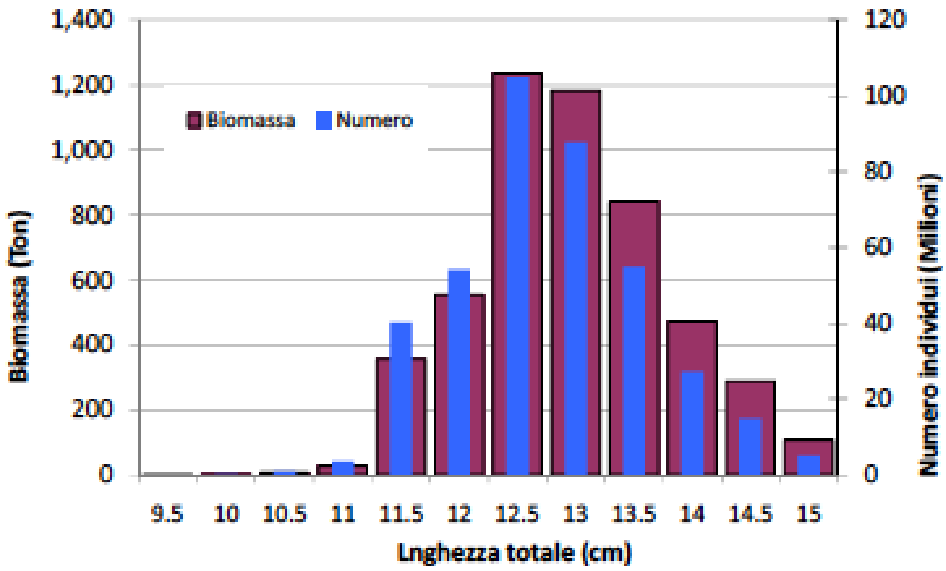


Fig. 4.2: Anchovy distribution by length, 2011 survey

4.1.2 Spatial distribution of the resources

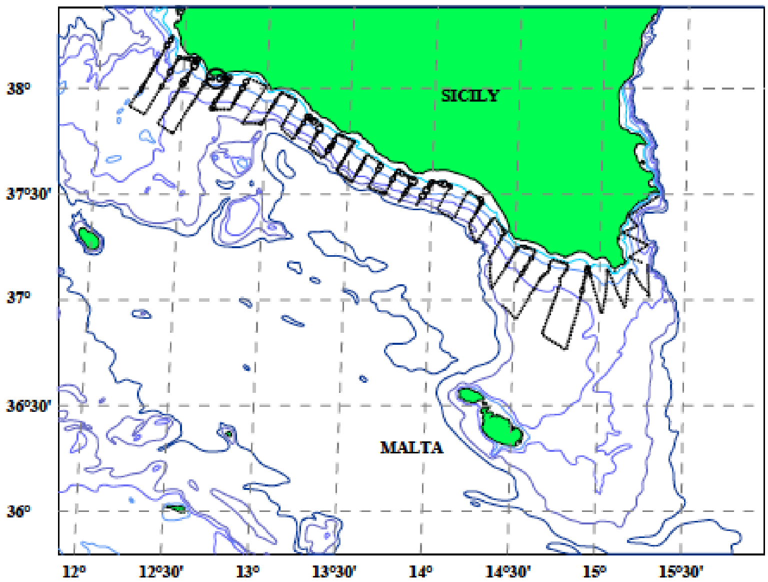


Fig. 4.3: Survey Ancheva 2009. Anchovy density spatial distribution (t/nm²)

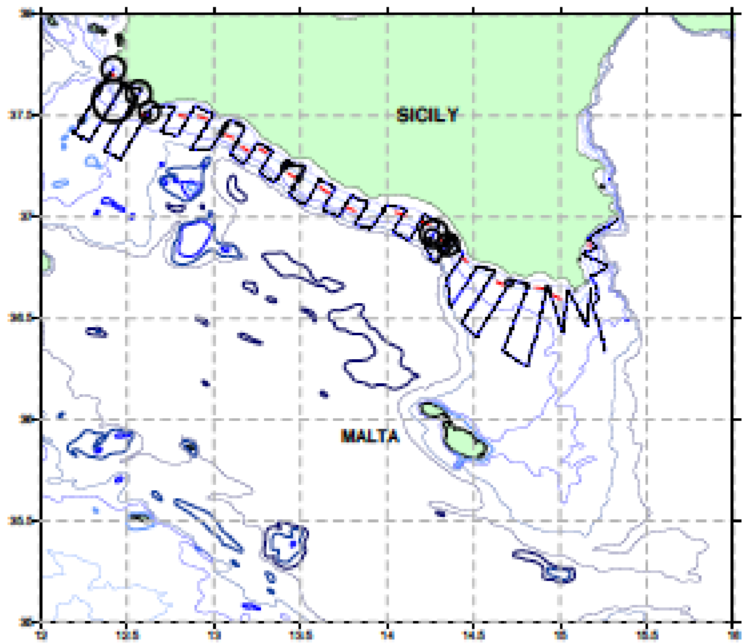


Fig. 4.4: Survey Ancheva 2010. Anchovy density spatial distribution (t/nm²)

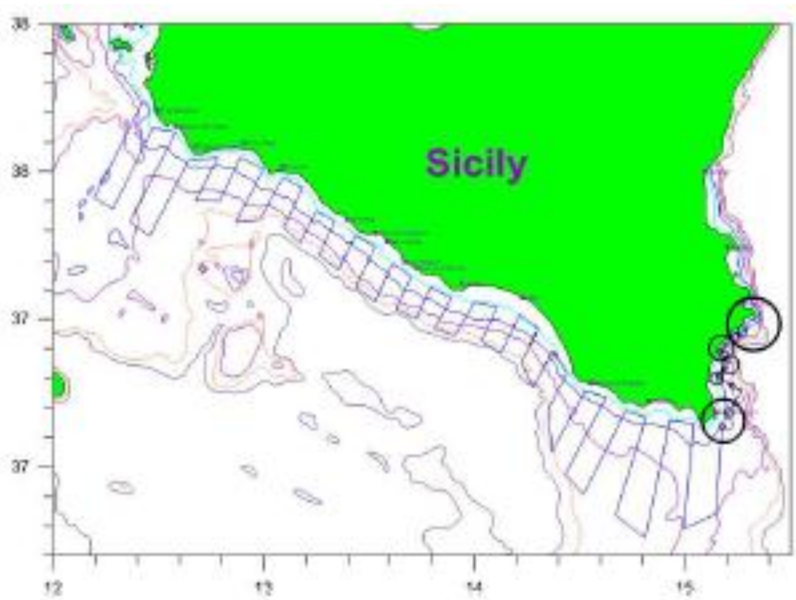


Fig. 4.5: Survey Ancheva 2011. Anchovy density spatial distribution (t/nm²)

4.1.3 Historical trends

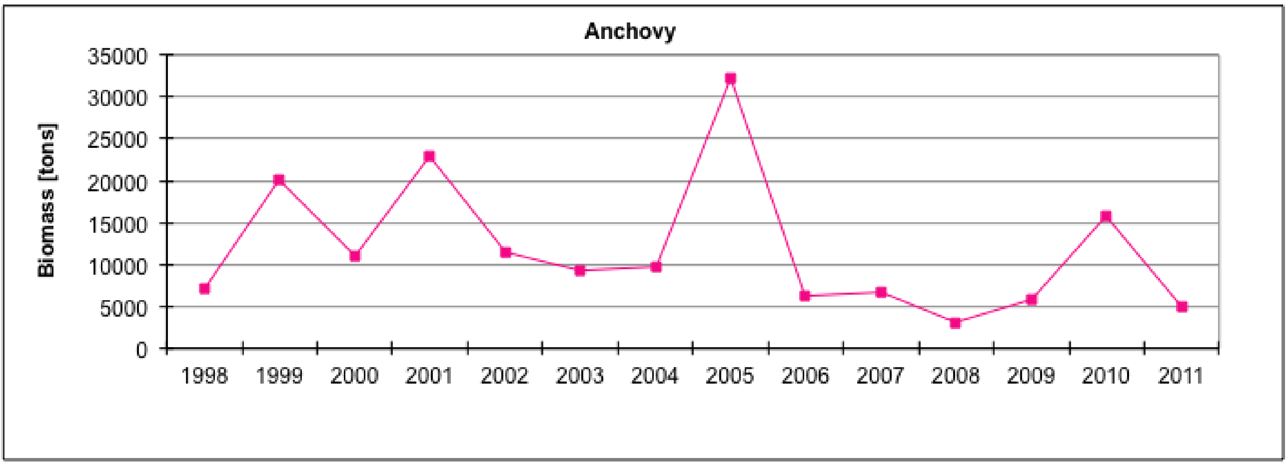


Fig. 4.6: Trends in anchovy biomass, years 1998-2011

Table 4.2: Estimated acoustic biomass values for anchovy stock as used in the assessment

Classification	Anchovy biomass
YEAR	(tons)
1998	7100
1999	20200
2000	11000
2001	22950
2002	11500
2003	9200
2004	9820
2005	20702
2006	6370
2007	6725
2008	3130
2009	5833
2010	15880
2011	5070
Average 1998-2011	11106

5 Ecological information

5.1 Protected species potentially affected by the fisheries

Dolphins' species: bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*).
Dolphins are reported to typically interact with fishing operations. However, by-catches occur only occasionally, as dolphins are usually able to prevent to be entangled.

5.2 Environmental indexes

The environmental index adopted and included in the modeling approach was the yearly average satellite-based (SeaWiFS and MODIS-Aqua) chlorophyll-a concentration estimate, calculated over the continental shelf of the study area.
Specifically, chl-a data NASA Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) and MODIS-Aqua projects, distributed as a Level 3 Standard Mapped Image product (Feldman and McClain, 2006), were used. Yearly composite images for the period 1998 to 2010 were downloaded from the http://oceancolor.gsfc.nasa.gov/cgi/l3 website in Hierarchical Data Format (HDF). These images have 2160 by 4320 pixels and a resolution of about 9 × 9 km^2.

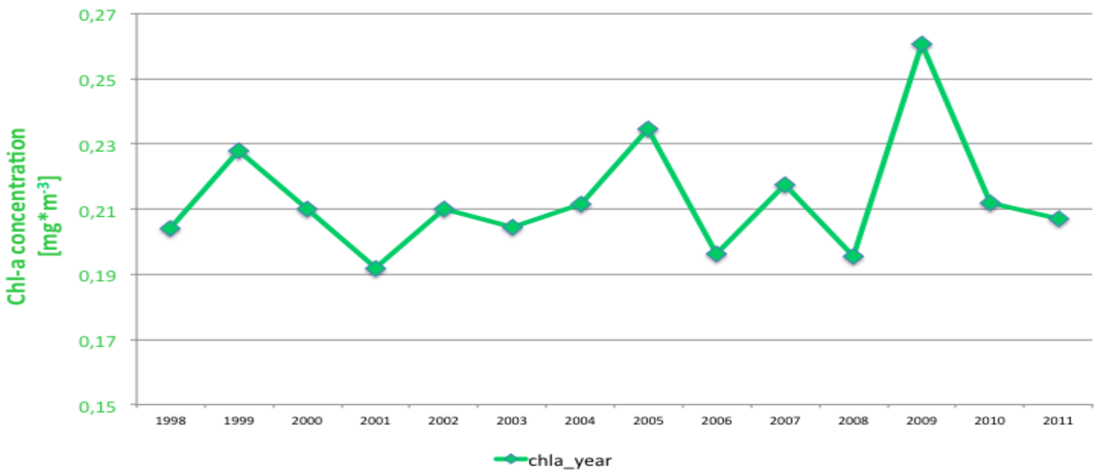


Figure 5.1: Mean annual chlorophyll concentration over the continental shelf of the study area from 1998 to 2011.

6 Stock Assessment

Two separate approaches were adopted:

- An empirical approach based on estimation of yearly and average (2008-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey);
- A modelling approach based on thefitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indeces, allowing for the optional incorporation of environmental indices, so that the r and/or K parameters of each year can be considered to depend on the corresponding value of the applied index.

6.1 Estimation of exploitation rates from harvest rates

6.1.1 Input data and model assumptions

The first approach for the evaluation of stock status, used in the present assessment, is based on the analysis of the harvest rates experienced in the available time series over the last years and on the related estimate of the current exploitation rate.
Landings data for GSA16 were obtained from DCF for the years 2006-2011 and from census information (on deck interviews) in Sciacca port (1998-2011). Acoustic data were used for fish biomass evaluations over the period 1998-2011. Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2009. Natural mortality was estimated following Pauly (1980) and by the Beverton & Holt's Invariants (BHI) method (Jensen, 1996). For the BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and k = 0.31.
The input data used for the stock was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2011. Available data were used to estimate yearly and average (2007-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey).
Actually, as long as this estimate of harvest rate can be considered as a proxy of F obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can also be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given.

6.1.2 Results

The high and increasing yearly harvest rates, as estimated by the ratio between total landings and stock sizes, indicate high fishing mortality levels.
The current (year 2011) harvest rate is 79.3% (DCF data were used for landings). The estimated average value over the years 2008-2011 is again 79.3%.
The exploitation rate corresponding to F=0.79 is E=0.55, if M=0.66, estimated with Pauly (1980) empirical equation, is assumed, and E=0.59 if M=0.56, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. Consequently, sing as reference point for the exploitation rate the 0.4 value suggested by Patterson (1992), this stock should be considered as being overexploited.

6.2 Non-equilibrium surplus production model

The anchovy stock in the area was also assessed using a non-equilibrium surplus production model based on the Schaefer (logistic) population growth model.
The model was implemented in an MS Excel spreadsheet, modified from the spreadsheets distributed by FAO under the BioDyn package (P. Barros, pers. comm.). Details about the implementation of the applied logistic modelling approach can be found in a FAO report on the Assessment of Small Pelagic Fish off Northwest Africa (FAO, 2004).
The report is available at the web site http://www.fao.org/docrep/007/y5823b/y5823b00.htm.

6.2.1 Input data and model assumptions

The input data used for the adopted modelling approach was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2011. Specifically, the time series of estimated total yearly anchovy landings for GSA 16 between 1998 and 2011 was used as input data for the model, together with the abundance indices from acoustic surveys from the same set of years.
Available data were used as input for the fitting of a non-equilibrium surplus production model to abundance indices, assuming an observation error model. The scientific surveys, mainly carried during early summer of each year, were considered to represent the stock abundance the same year. In addition an enviromental index, the satellite based estimate of yearly average chlorophyll-a concentration over the continental shelf off the southern sicilian coast, was used in the attempt of improving the performance of the model fitting, as expected because pelagic stocks are known to be significantly affected by environmental variability.
The model uses four basic parameters: Carring capacity (or Virgin Biomass) K, population intrinsic growth rate r, initial depletion BI/K (starting biomass relative to K) and catchability q. Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the MSY, B_{MSY} and F_{MSY} reference points.
Derived reference points were also evaluated: B_{Cur}/B_{MSY}, indicating whether the estimated stock biomass, in any given year, is above or below the biomass producing the MSY, and F_{Cur}/FSY_{Cur} (the ratio between the fishing effort in the last year of the data series and the effort that would have produced the sustainable yield at the biomass levels estimated in the same year), indicating whether the estimated fishing mortality, in any given year, is above or below the fishing mortality producing the sustainable (in relation to natural production) yield in that year.
Values of F_{Cur}/FSY_{Cur} below 100% indicate that the catch currently taken is lower than the natural production of the stock, and thus that so stock biomass is expected to increase the following year, while values above 100% indicate a situation where fishing mortality exceeds the stock natural production, and thus where stock biomass will decline next year. For comparison purposes, also the series of F_{Cur}/F_{MSY} was evaluated and reported.

6.2.2 Results

The results of the second assessment approach, which is based on the implementation of a non-equilibrium logistic surplus production model, are consistent with the previous considerations about trends in harvest rates and in estimated exploitation rates.

The fluctuations in stock biomass cannot be explained solely by the observed fishing pattern. This was an expected result, as pelagic stocks are known to be significantly affected by environmental variability. The incorporation of an environmental index in the model, significantly improved the fitting of the model, allowing the stock to grow more or less than average depending on the state of the environment in each year.

Model performance was quite poor (R^2 = 0.11) without incorporating the environmental effect, significantly higher (R^2 = 0.45; Fig. 6.2.2-1) when adopting in the model formulation a variable population intrinsic growth rate *r*, considered to be positively affected by chlorophyll-a concentration at sea (exponential effect).

In the current adopted formulation, satellite-based data on chlorophyll concentration showed to have a positive effect on the yearly population intrinsic growth rate. Current (year 2011) fishing mortality is far above the sustainable fishing mortality at current biomass levels (F_{Cur}/FSY_{Cur}=3.15; F_{MSY}=0.17; F_{Cur}/F_{MSY}=4.54; see Table 6.2.2-1). Fishing mortality experienced very high values during the considered period, frequently well above sustainability (F_{Cur}/FSY_{Cur}>1; Fig. 6.2.2-2). In addition, B_i/B_{MSY} values were below 100% over the entire time series (B_{MSY} = 14152 tons; B_{Cur}/B_{MSY} = 0.56; Fig. 6.2.2-3), and estimated average production of the last three years (5160 tons) is well above the MSY (2359 tons).

Table 6.1: Reference points.

MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
2359	14152	0.17	56%	315%	454%

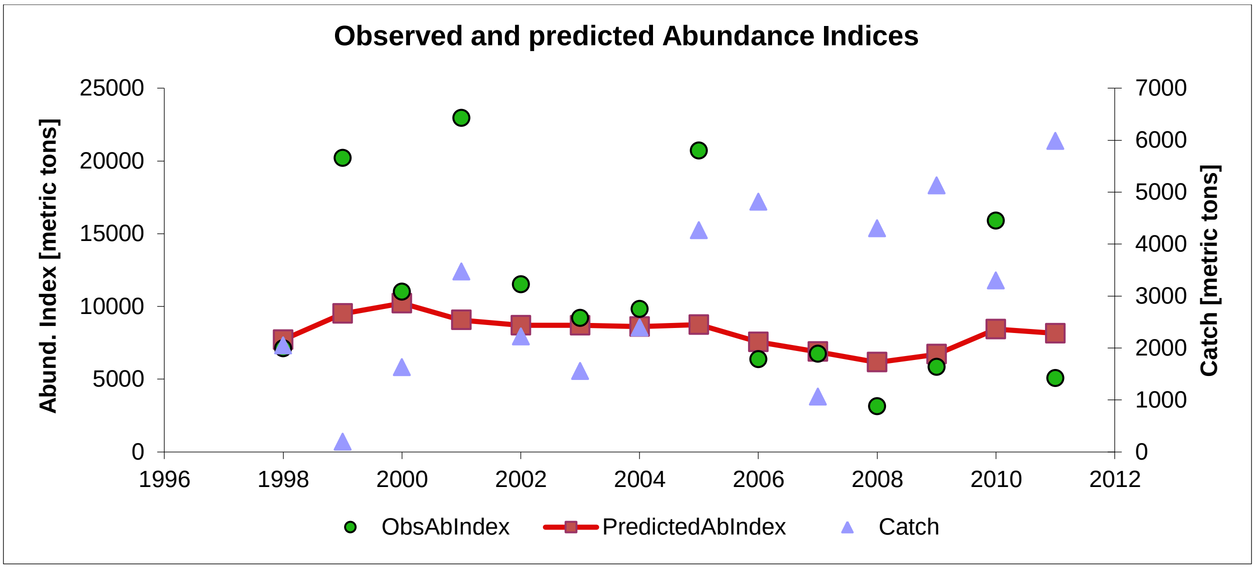


Figure 6.1: Best fit obtained with a flexible intrinsic growth rate "r", modulated by chl-a concentration at sea.

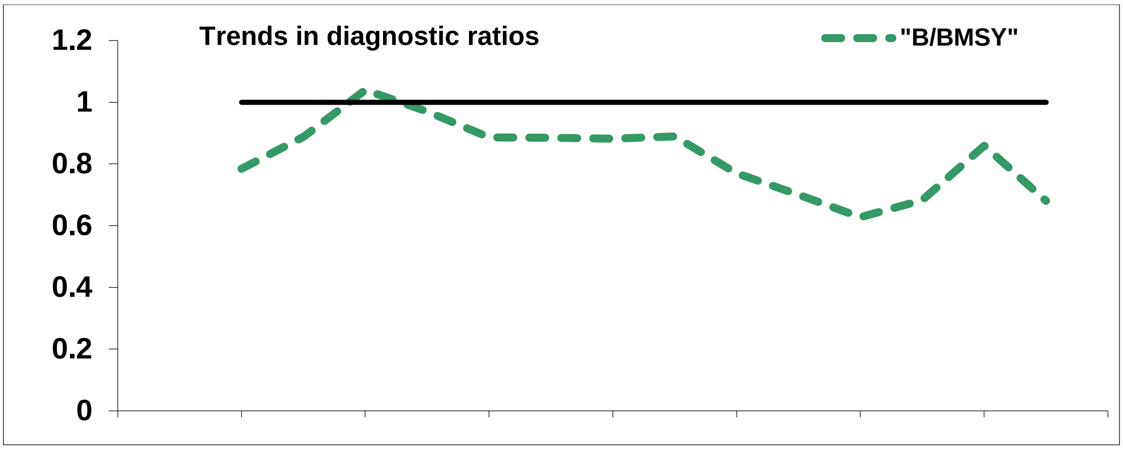


Figure 6.2: Trend in ratio between current biomass (B) and B_{MSY} over 1998-2011.

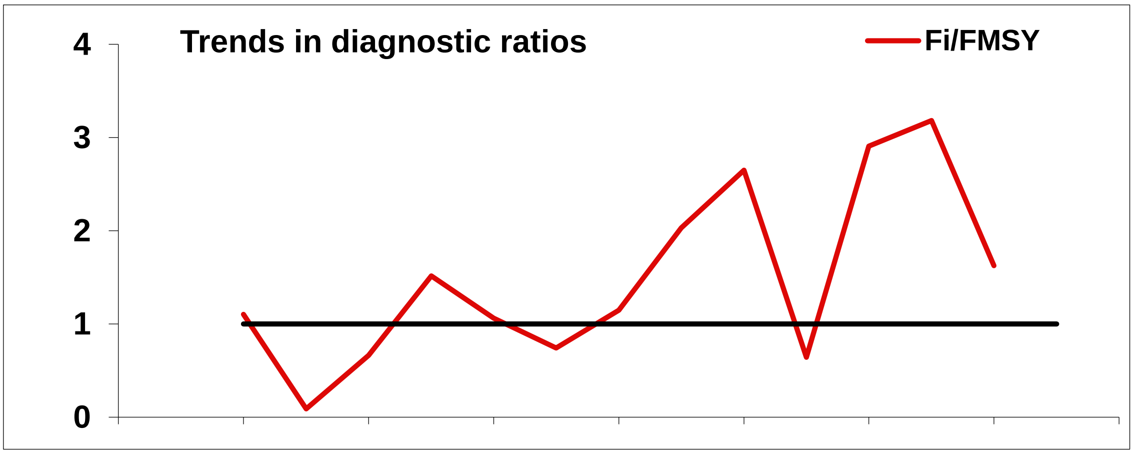


Figure 6.3: Trend in ratio between current fishing mortality (F) and F_{MSY} over 1998-2011.

6.3 Robustness analysis

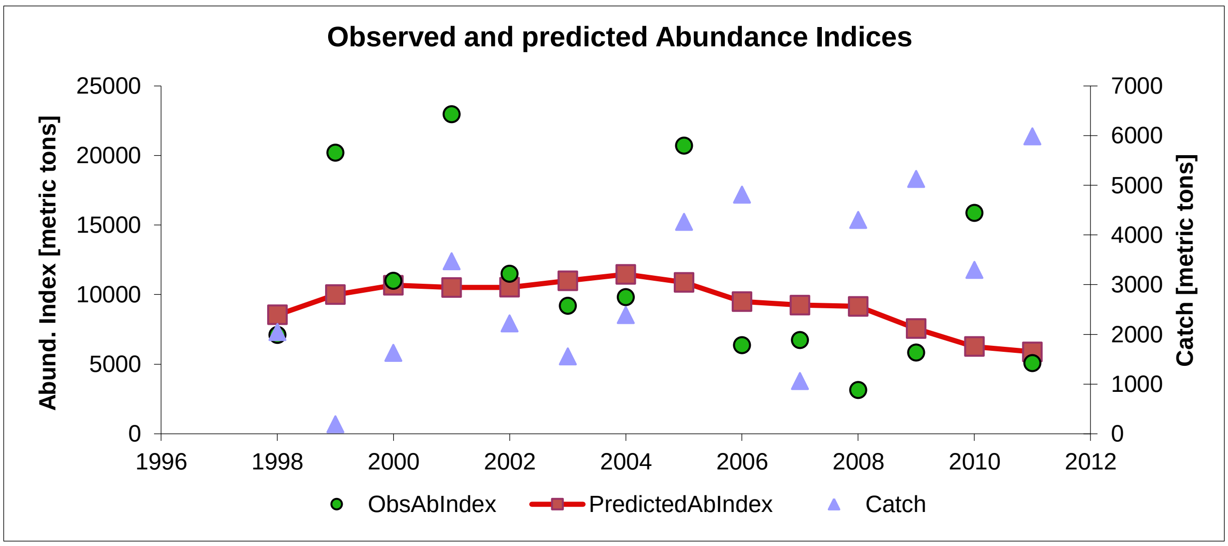


Figure 6.4: Best fit obtained without incorporating the environmental.

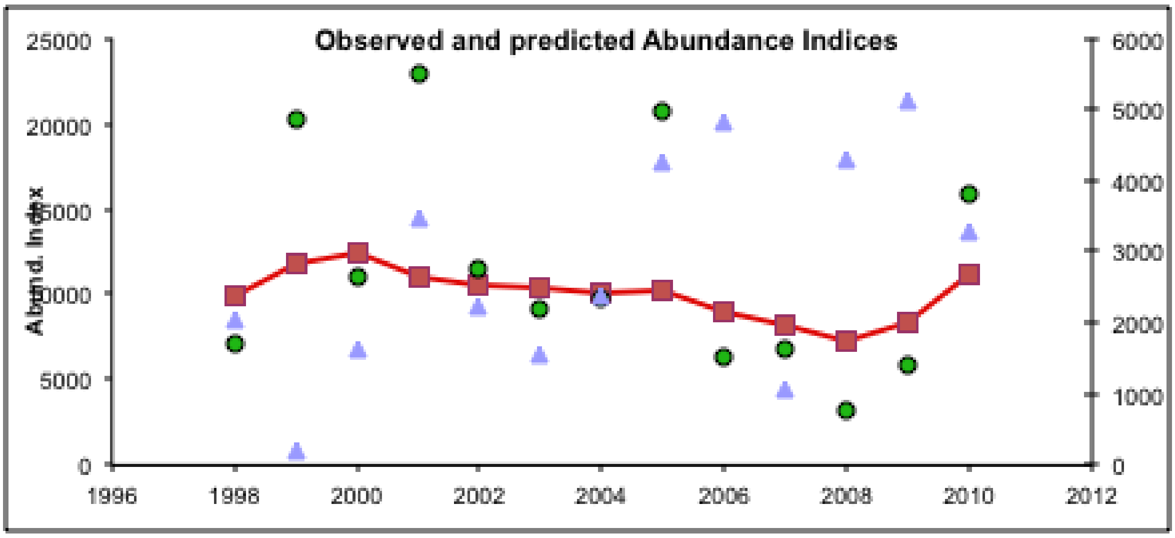


Figure 6.5: Results of the retrospective analysis run, obtained using data from 1998 to 2010. Best fit with a flexible intrinsic growth rate "r", modulated by chl-a concentration at sea.

Table 6.2: Reference points for the retrospective analysis run and for the best fit obtained including updated data (2011).

Year	MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
2010	2198	17584	0.13	85%	153%	176%
2011	2359	14152	0.17	56%	315%	454%

6.4 Assessment quality

The quality of input data is good and the obtained output is reasonable, even though the goodness of the best fit obtained using the surplus production modeling approach is limited.
The results of the adopted modeling approach are consistent with those ones obtained from the estimation of exploitation rates based on the analysis of harvest rate time series, as in both cases the current fishing mortality levels are estimated to be above sustainability.
Results of the retrospective analysis are also satisfactory.

7 Stock predictions

No predictions were conduct during GFCM WG.

8 Draft scientific advice

8.1 Diagnosis of stock status

The present diagnosis of stock status is based on the evaluation of current exploitation pattern and biomass levels. The adopted reference points (RP) for fishing mortality were E=0.4 (Patterson) and FMSY, whereas for biomass level the WG proposed the use of both B_{MSY} and a new set of RP (B_{lim} and B_{pa}) as defined below.

Results of the adopted modeling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels and indicate that the stock abundance was below the B_{MSY} during the last years.

In addition, fishing levels over the last years are increasing and higher than those required for extracting the MSY of the resource.

A tentative B_{lim} was discussed and adopted by the WG as the lowest value observed in the last year of the series. Similarly, B_{pa} was established as B_{lim}*1.4.

Using the above reported RP, the current biomass estimate (5070 tons, 2011 value) is well below B_{MSY} (14152 tons), but it is above the adopted estimated B_{lim} (3130 tons) and also slightly, even not significantly, above B_{pa} (4382 tons) (Fig.7-1).

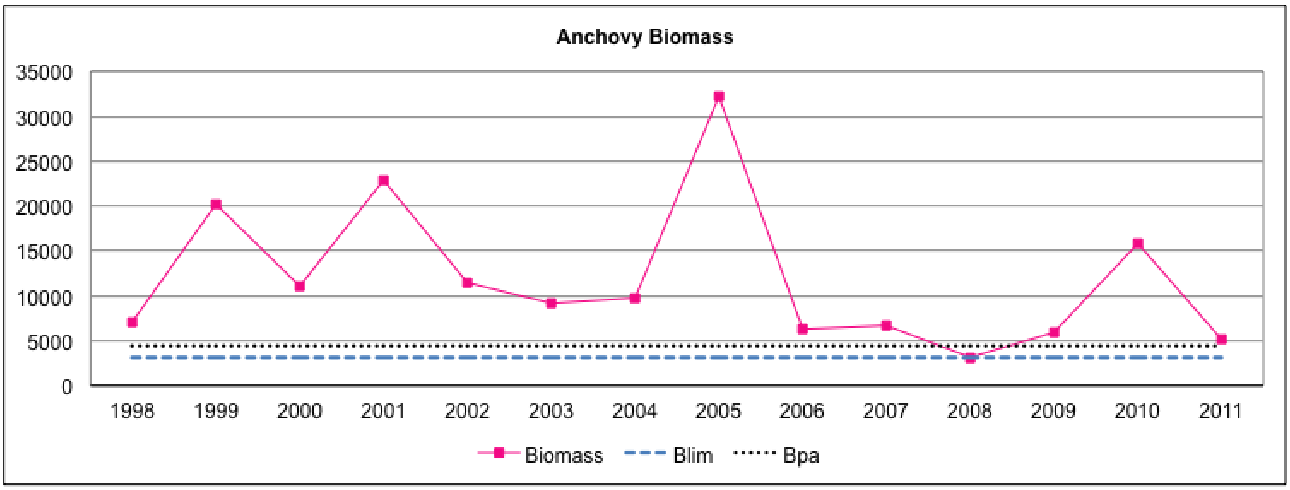


Figure 8.1: Trends in anchovy biomass (tons), years 1998-2011. Blim and Bpa are also indicated.

Table 8.1: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
1998-2011		1998-2011	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
X	High fishing mortality	**X**	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table 8.2: Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
1998-2011		N.A.	
6000-36370 tons		[Range]	
	Stable		Stable
	Increasing		Increasing
X	Decreasing		Decreasing

8.2 Advices and recommendations

Given that the stock is currently overexploited, fishing effort should be reduced by means of a multi-annual management plan until there is evidence for stock recovery. Consistent catch reductions along with effort reductions should be determined. However, the mixed fisheries effects, mainly the interaction with sardine, need to be taken into account when managing the anchovy fishery. As the small pelagic fishery is generally multispecies, any management of fishing effort targeting the anchovy stock would also have effects on sardine. Local small pelagic fishery appears to be able to adapt at resource availability and market constraints, targeting the fishing effort mainly on anchovy. But due to the low biomass levels experienced by the anchovy stock over the last years, measures should be taken to prevent a possible further shift of effort back from anchovy to sardine.

8.3 Discussion

The present assessment, based on the analysis of the abundance and fishing mortality levels observed in the available time series, implied the tentative precautionary evaluation of sustainable levels for current exploitation rates and for current biomass, also taking into the contrasting perspective between the model output, showing a relative stable trend, and the raw data.

9 References

Jensen, A.L. (1996). Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can. J. Fish. Aquat. Sci., 53: 820-822.

Patterson, K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. Review of Fish Biology and Fisheries, 2: 321-338.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer, 39 (3): 175-192.

Stock Assessment Form

Sardine in GSA 17 (Northern Adriatic Sea)

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1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Sardina pilchardus	Sardine	35 - Herrings, sardines, anchovies
Geographical sub-area:		
GSA 17		
Stock assessment method: (direct, indirect, combined, none)		
Combined		
Authors: Carpi P. (1), (*in alphabetical order)* Angelini S. (1), Belardinelli A. (1), Biagiotti I. (1), Campanella F. (1), Canduci G. (1), Cingolani N. (1), Čikeš Keč V.(2), Colella S. (1), Croci C. (1), De Felice A. (1), Donato F.(1), Leonori I. (1), Martinelli M. (1), Malavolti S. (1), Modic T. (3), Panfili M. (1), Pengal P. (3), Santojanni A. (1), Tičina V. (2), Vasapollo C. (1), Zorica B. (2), Arneri E (4).		
1		
Affiliation: (1) CNR-ISMAR (Ancona, Italy), (2) Institute of Oceanography and Fisheries (Split, Croatia), (3) Fisheries Research Institute of Slovenia (Ljubjana, Slovenia), (4) FAO-Adriamed (Rome, Italy)		

2 Stock identification and biological information.

2.1 Stock unit

Sardine stock is shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia) and constitutes a unique stock.
Although there is some evidence of differences on a series of morphometric, meristic, serological and ecological characteristics, the lack of genetic heterogeneity in the Adriatic stock has been demonstrated through allozymic and mitochondrial DNA (mtDNA) surveys (Carvalho et al. 1994) and through sequence variation analysis of a 307-bp cytochrome *b* gene (Tinti et al. 2002a,b). The results of the genetic analyses imply that the different trophic and environmental conditions found in the northern and central Adriatic, may cause differences in growth rates.

2.2 Growth and maturity

Table 2.2.1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*			TL		Units*	cm
Sex	Fem	Mal	Both	Unexsed		
Maximum size observed			21.5		Reproduction season	October-May
Size at first maturity			8		Reproduction areas	Mainly Central Adriatic, eastern offshore areas. Between Susak Island and Jabuka Pit, and around Palagruza.
Recruitment size			9		Nursery areas	River Po delta, Manfredonia Gulf

Table 2.2.2: Growth and length weight model parameters.

			Sex			
		Units	female	male	both	unsexed
Growth model	L∞	Cm			20.5	
	K	y^{-1}			0.46	
	t0	y			-0.5	
	Data source	Sinovcic,1984				
Length weight relationship	a				0.0056	
	b				3.0327	

	Age0	Age1	Age2	Age3	Age4	Age5	Age6		
M (vector by age) Gislason *et al*, 2010	2.51	1.10	0.76	0.62	0.56	0.52	0.50		

sex ratio (% females/total)	

3 Fisheries information

3.1 Description of the fleet

Table 3.1.1: Description of operational units in the stock.

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	Italy	17	Pelagic trawlers	Trawls	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 2	Italy	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 3	Croatia	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 4	Slovenia	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Sardine pilchardus
Operational Unit 5	Slovenia	17	Pelagic trawlers	Trawls	35 - Herrings, sardines, anchovies	Sardine pilchardus

Table 3.1.2: Catch, bycatch, discards and effort by operational unit.

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
1	84	tons	6800				
2	19	tons	486				
3	NA	tons	46000				
4	5	tons	300				
5	1						
Total	130						

Table 3.1.3: Catches as used in the assessment.

Classification (age, length, recruit/spawner)	Catch (tn)
2000	23558
2001	21242
2002	24459
2003	22028
2004	21671
2005	19008
2006	19759
2007	20329
2008	25566
2009	33279
2010	33301
2011	52546
Average	26396

3.2 Historical trends

In figure 3.2.1 the trend in landings for Italy and Croatia are shown. Since 2005 the trend is constantly increasing reaching the maximum in the last year: the 2011 catches (52546 tons) are the highest ever registered from 1975. The Slovenian catches are included in the total landings but are not shown here since the quantities are really low (around 300 tons in 2011):

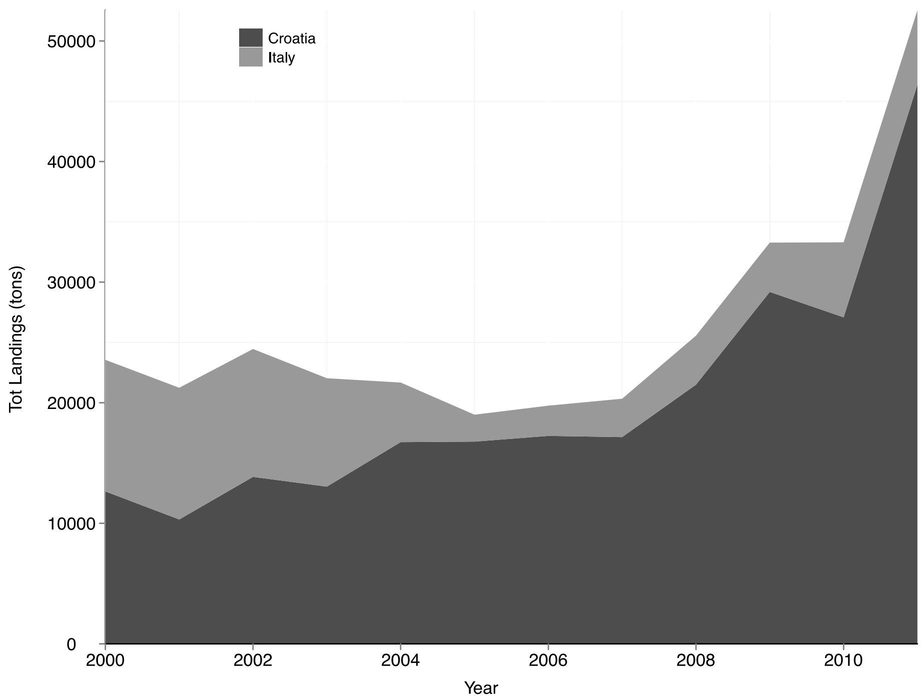

Figure 3.1: Total landings (in tons) by country for GSA 17 from 2000 to 2011.

The trend of the cohorts in the catches is shown in figure 3.2.2. Each plot represents the number of fish of each age born in the same year. Age 2 can be identified as the first fully recruited age.

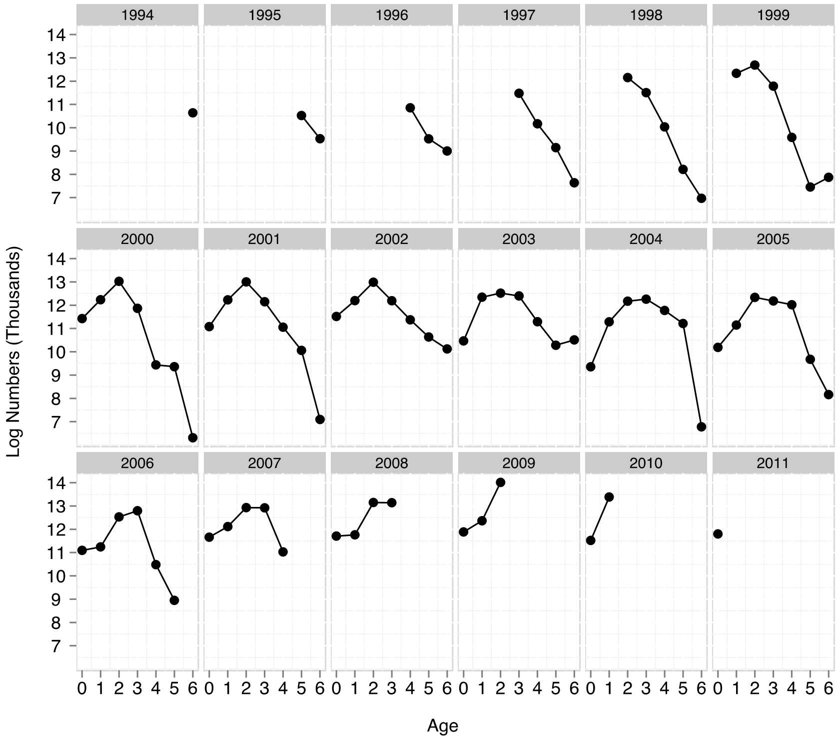

Figure 3.2.1: Log numbers at age (thousands) of the catch at age used in the assessment.

The mean weight at age (in kg) as obtained by sampling of commercial catches is given in figure 3.2.3.

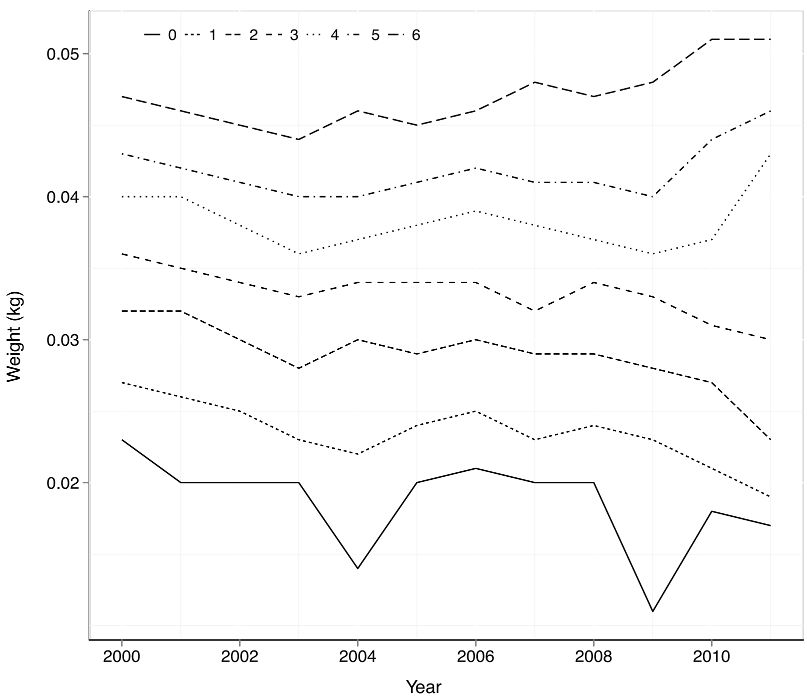

Figure 3.2.3: Mean weight at age (kg) in the catches.

3.3 *Management regulations*

A closure period is observed from the Italian pelagic trawlers on August, and from 15th December to 15th January from the Croatian purse seiners. In 2011 a closure period of 60 days (August and September) was endorsed by the Italian fleet.

3.4 *Reference points*

The present assessment has been considered as a benchmark assessment for biomass reference points. Up to now, the Patterson's reference point of E=0.4 has been adopted as fishing mortality reference point.

The reference points that were proposed during the working group are B_{lim} and B_{pa}. The criterion adopted for B_{lim} has been the minimum mid year biomass value of the assessed time series, which is of the same magnitude of the minimum value observed since 1976, so it seemed to be reasonable. B_{pa} has been established in relation to B_{lim} using an estimate or assumption on the coefficient of variance of the estimates (see general sections), and assuming that the confidence intervals for the estimate of the assessment model are estimate ± 2 * CV * estimate. In this case a CV of 20 % has been assumed, therefore B_{pa} has been established as 40% above B_{lim}.

Table 3.4: List of reference points

Criterion	Current value	Units	Reference Point	Trend	Comments
B					
SSB					
F					
Y					
CPUE					
E(1-4)	0.52		0.4	Increasing	Patterson (1992)
Blim	215050	tons	78000	Increasing	
Bpa	215050	tons	109200	Increasing	

4 Fisheries independent information

4.1 MEDIAS ECHOSURVEY (Acoustic survey)

4.1.1 Brief description of the chosen method and assumptions used

Echosurveys were carried out from 2004 to 2011 for the entire GSA 17. In the western part the acoustic survey was carried out since 1976 in the Northern Adriatic (2/3 of the area) and since 1987 also in the Mid Adriatic (1/3 of the area), and it is in the MEDIAS framework since 2009. The eastern part was covered by Croatian national pelagic monitoring program PELMON. The data from both the surveys have been combined to provide an overall estimate of numbers-at-age.

The survey methods for MEDIAS are given in the MEDIAS handbook (MEDIAS, March 2012).

Western Echosurvey:

- Length frequencies distribution available from 2004 onward (no LFD for Mid Adriatic in 2004, so the biomass at length in 2004 was assumed equal to the proportion of biomass at length in the 2005 Mid Adriatic survey).
- ALKs available for 2009-2010-2011;
- Numbers at age for 2004 to 2008 were obtained applying the sum of the 2009-2010-2011 ALKs to the numbers at length.

Eastern Echosurvey:

- Length frequencies distribution available from 2009.
- No ALKs available.
- Numbers at length from 2004 to 2008 were obtained applying the length frequency distribution from the 2009 survey to the total biomass.
- Numbers at age were obtained applying commercial ALK from the eastern catches to the eastern echosurvey length distribution.
- 2011 survey covered only the Northern part of the area (about 52% of the total area), so the estimated biomass was raised to the total using an average percentage from previous years (2004-2010).

4.1.2 Spatial distribution of the resources

Acoustic sampling transects and the total area covered are shown in figure 4.1.

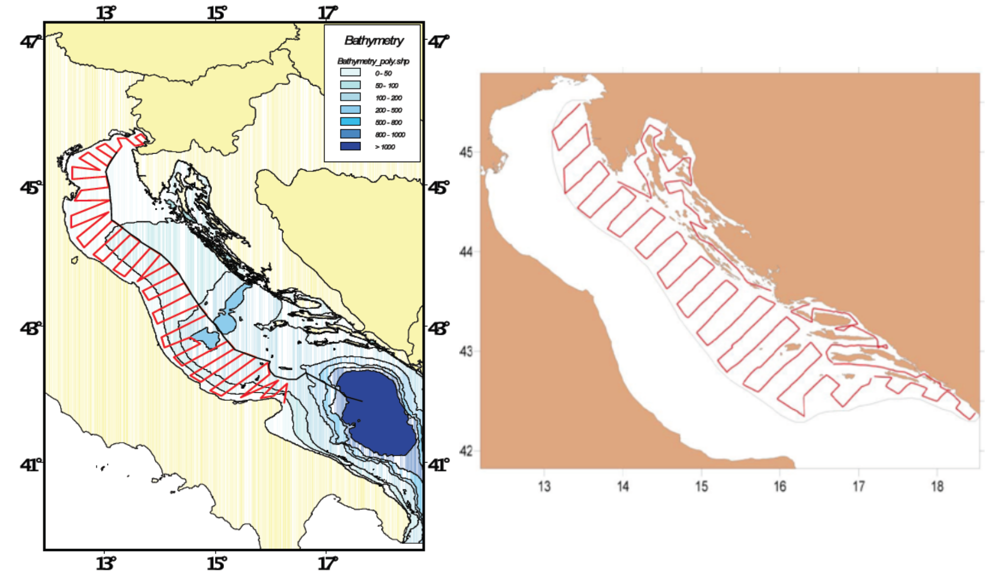

Figure 4.1: Acoustic transects for the western echosurvey (on the left) and the eastern echosurvey (on the right).

4.1.3 Historical trends

Biomass estimates from the two surveys show a general higher occurrence of sardine on the eastern side of the Adriatic. Nevertheless, in 2011 the western survey contributed to about 83% of the total estimated biomass.

Pooled total biomass in tons from eastern and western echosurvey (2004-2011) is given in table 4.1 and it is shown in figure 4.2.

Table 4.1: Total biomass (tons) estimated by the acoustic surveys in GSA 17.

	Tons
2004	287675
2005	140082
2006	312793
2007	217897
2008	272370
2009	365939
2010	258130
2011	483224

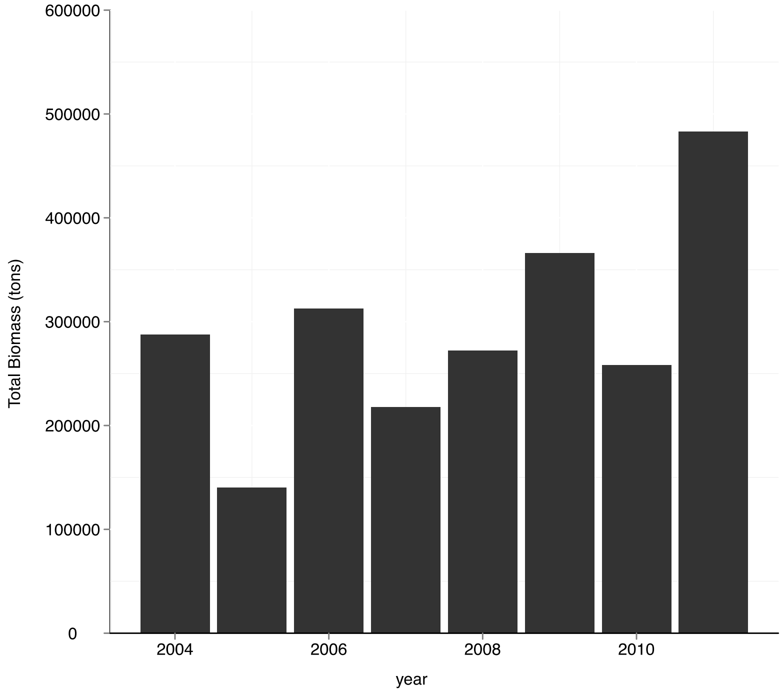

Figure 4.2: Total biomass (tons) estimated from the eastern and western echosurvey.

Figure 4.3 illustrates the proportion by year of each age class from the surveys. In 2009 and 2011 higher percentage of age 0 has occurred. Age 5 and age 6 are scarcely represented in the estimation.

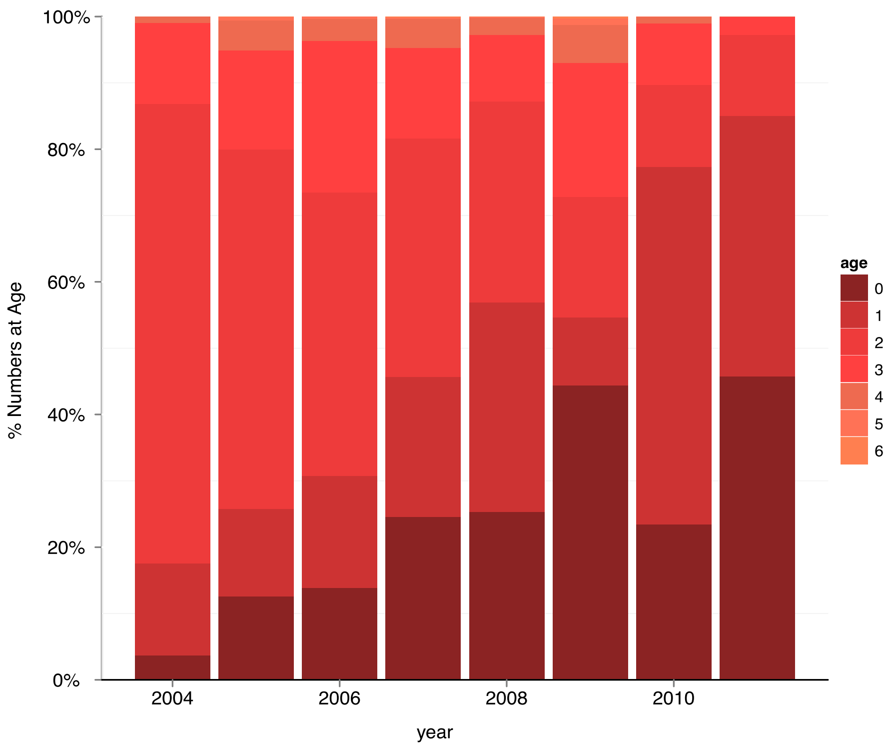

Figure 4.3: Total proportion of age classes for the two surveys.

In figure 4.4 the trend of the cohorts in the acoustic survey is shown. Each plot represents the number of fish of each age born in the same year:

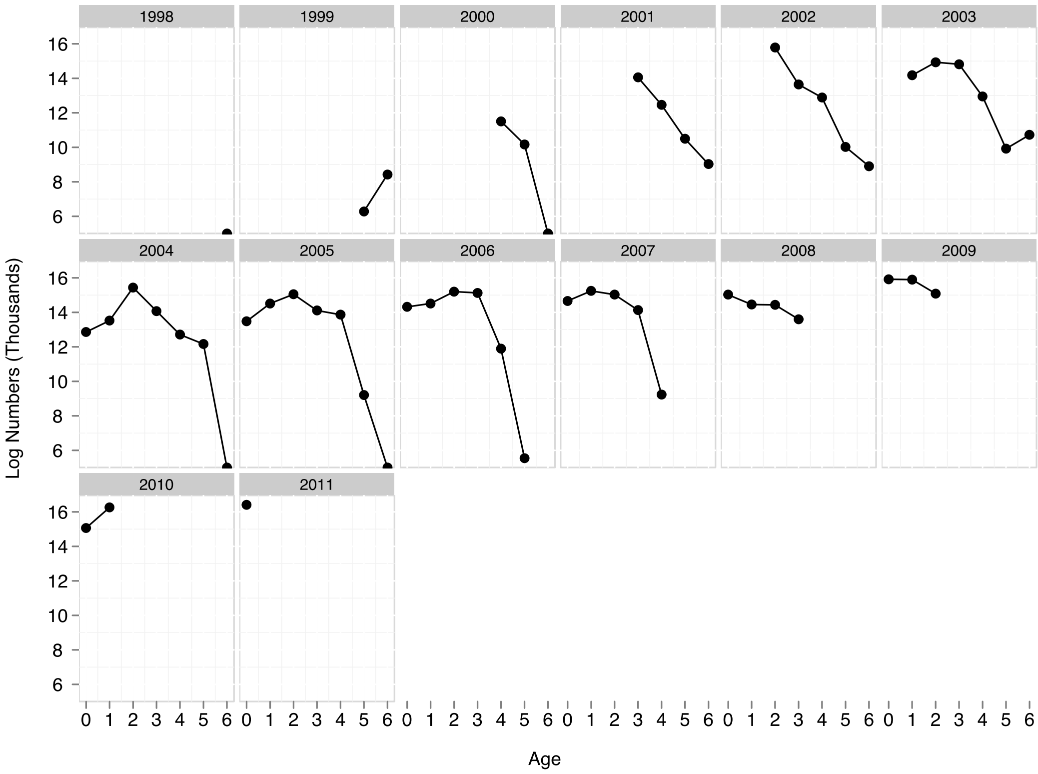

Figure 4.4: Log numbers at age (thousands) of the echosurvey index used in the assessment.

4.2 MEDITS

4.2.1 Brief description of the chosen method and assumptions used

The MEDITS bottom trawl survey started in 1994 and it has been carried out every year since. It takes place during the summer months (June-July) and it provides indices of fish abundance in the deepest part of water column (i.e. within layer up to 3 m above sea bed). Although this survey is targeted to investigate species living near the bottom, the characteristics of the net employed (high vertical opening of the mouth) allow to regularly catch species living in the water column, as small pelagics (Sbrana *et al.,* 2010).

The survey methodology is given in the MEDITS handbook (MEDITS, April 2012).

4.2.2 Spatial distribution of the resources

The spatial distribution of the Medits stations during the 2010 trawl survey is illustrated in figure 4.5.

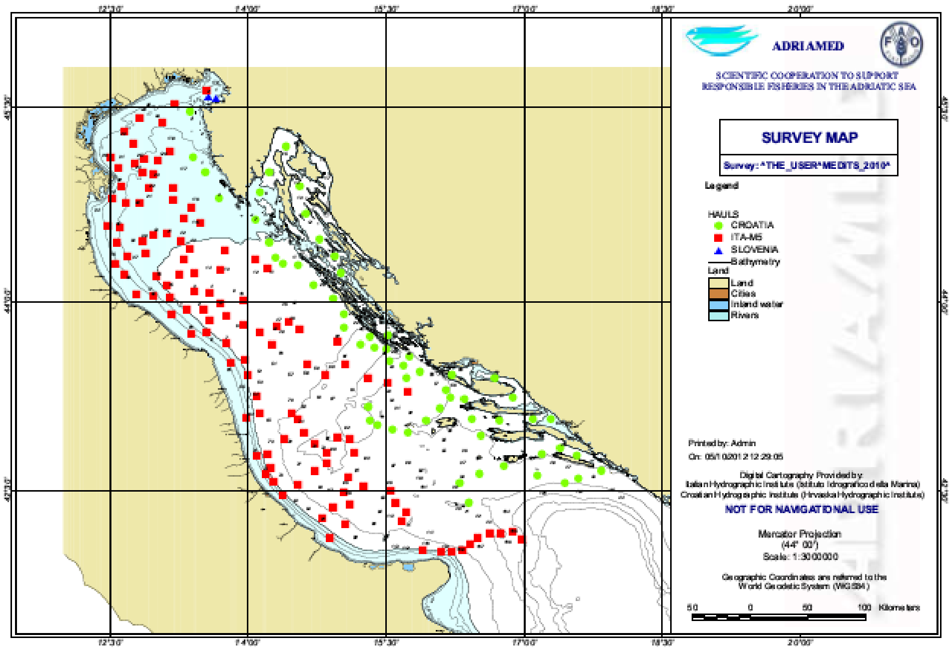

Figure 4.5: Spatial distribution of the MEDITS stations in GSA 17.

4.2.3 Historical trends

The biomass index (kg/km²) (table 4.2) shows an overall decreasing trend up to 2007, followed by a constant increase, with a maximum in 2011 (29.97 Kg/km²).

Table 4.1: MEDITS index of biomass (kg/km2) from 2000 to 2011.

Medits biomass index	kg/km2
2000	9.85
2001	12.59
2002	15.05
2003	10.96
2004	18.69
2005	4.04
2006	5.90
2007	3.18
2008	6.58
2009	6.89
2010	8.74
2011	29.97

The comparison between the acoustic series of total biomass and the trawl survey biomass index shows a general agreement between the two indices (figure 4.6). The only exception is 2010, when the bottom trawl survey sees an increasing trend while the acoustic one sees a

slightly decrease. In 2011 both the surveys show a steep increase, which is reflected in the 2011 landings from the eastern side as well.
The weight given in the assessment to the MEDITS trawl survey is much lower to the weight given to the acoustic survey (see section 7.1.1).

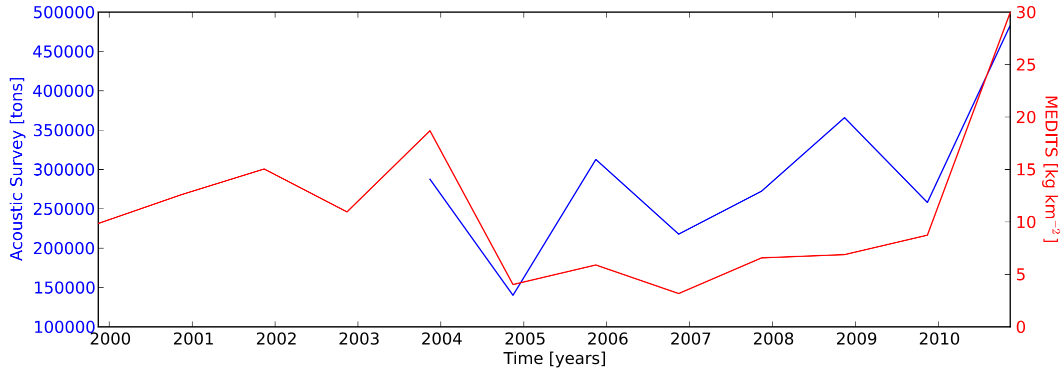

Figure 4.6: Comparison between biomass index from the acoustic survey (axis on the left, blue line) and the bottom trawl survey (axis on the right, red line).

5 Ecological information

N/A

5.1 Protected species potentially affected by the fisheries

N/A

5.2 Environmental indexes

N/A

6 Stock Assessment

Integrated Catch Analysis (ICA) and Virtual Population Analysis (VPA) have been performed from 2000 to 2011.
Acoustic and bottom trawl survey were available for the assessment of sardine in GSA 17. The weight given to the bottom trawl survey was decided equal to 0.3, in comparison to weight 1 given to the acoustic survey.
Age 0 wasn't included in the model: the high natural mortality, in fact, drives the biomass to really high –and quite unrealistic- values. Since age 0 is not largely represented in the catches, the WG decided not to include it in the assessment.

6.1 Integrated Catch Analysis

The final assessment of anchovy was carried out by fitting the integrated catch-at age model (ICA) with a separable constraint over a seven-year period, tuned with the Acoustic survey (2004-2011) and bottom trawl survey biomass index (2000-2011).
ICA was performed using the Patterson's software (ICA, version 4.2 – Patterson and Melvin, 1996).
The model settings are presented in section 6.1.1.

6.1.1 Model assumptions

- Ages 1 to 6
- M vector estimated using Gislason's equation (Gislason *et al*., 2010):

Age1	Age2	Age3	Age4	Age5	Age6
1.10	0.76	0.62	0.56	0.52	0.50

- Maturity at age:

Age1	Age2	Age3	Age4	Age5	Age6
1	1	1	1	1	1

- 7 years for separable constraint
- Reference age for separable constraint = 2
- Constant selection pattern model
- S to be fixed on last age = 1.3
- F_{bar}: 1-4
- Catchability model = Linear
- Weight for surveys: Bottom trawl surveys= 0.3; Acoustic surveys = 1.
- No shrinkage

6.1.2 Scripts

N/A

6.1.3 Results

The fishing mortality for age 2 (presented in figure 6.1, top-right) shows a steep increase from 2005 (RefF = 0.14) up to 2011 (RefF = 0.80). In 2011 the $F_{bar(1\text{-}4)}$ is equal to 1.11.
The mid-year biomass (figure 6.1, bottom-right) is fluctuating between about 100000 t and about 200000 t until 2009, in which the trend starts a constant increase reaching the maximum of 215000 tons in 2011.
The recruitment (age 1 – figure 6.1, bottom-left) is quite stable as well, but again in 2009 begin to growth up to the value of 16830000 thousands specimens in 2011.

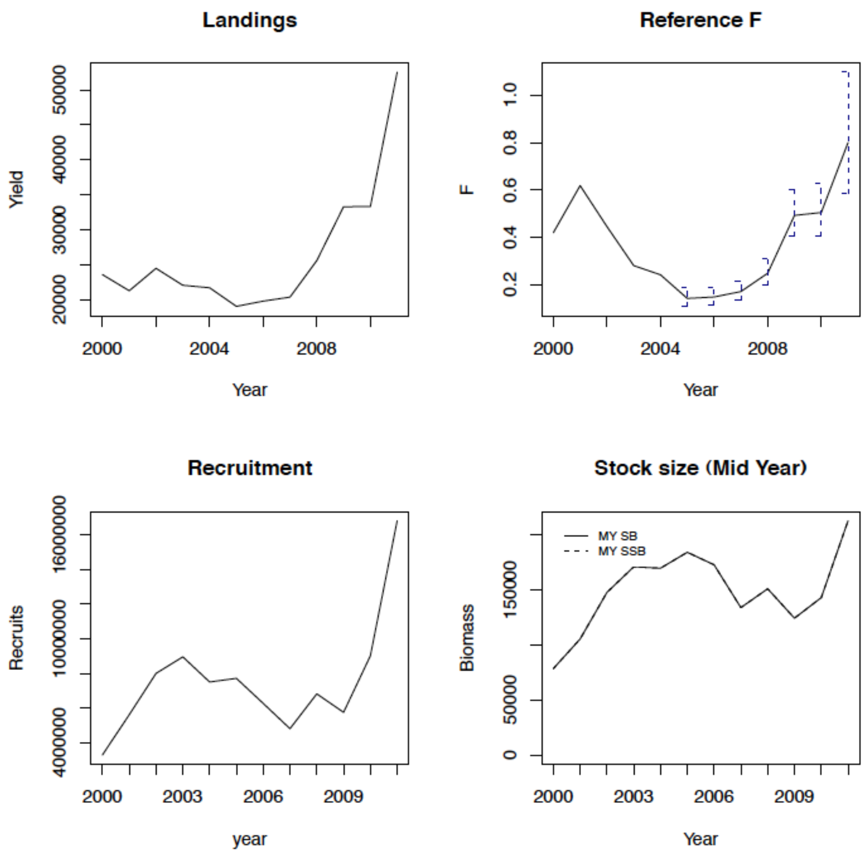

Figure 6.1: Total landings in tons (top-left); reference F (F for age 2) with the confidence interval for the separability period (top-right); recruitment (as thousands individuals)(bottom-left); mid year stock biomass and SSB in tons (bottom-right).

Table 6.1 and 6.2 give respectively the stock numbers at age by year (in thousand) and the fishing mortality at age by year. In table 6.3 the mid-year stock biomass and the spawning stock biomass in tons are presented.

Table 6.1: Stock numbers at age by year (thousands).

	Age1	Age2	Age3	Age4	Age5	Age6
2000	3276600	769120	278820	140330	136270	151380
2001	5605400	967120	236540	82268	42443	42384
2002	7997100	1753200	243670	58144	27956	24004
2003	8953900	2549900	525200	41413	16735	9388
2004	7500200	2872100	901120	181860	13090	8000
2005	7710200	2371300	1055200	350810	94557	19704
2006	6261900	2526000	962890	406350	149410	3981
2007	4797400	2050100	1019300	365340	170820	7662
2008	6813200	1566600	808550	366370	146450	112770
2009	5742600	2205500	571770	241900	125010	96016
2010	9015800	1808500	630310	95891	49645	2255
2011	16830000	2835500	510630	102720	19191	6610

Table 6.2: Fishing mortality at age by year.

	Age1	Age2	Age3	Age4	Age5	Age6
2000	0.120	0.419	0.601	0.636	0.424	0.424
2001	0.062	0.619	0.783	0.519	0.520	0.520
2002	0.043	0.445	1.152	0.685	0.547	0.547
2003	0.037	0.280	0.441	0.592	0.326	0.326
2004	0.052	0.241	0.323	0.094	0.183	0.183
2005	0.016	0.141	0.334	0.294	0.184	0.184
2006	0.017	0.148	0.349	0.307	0.192	0.192
2007	0.019	0.170	0.403	0.354	0.222	0.222
2008	0.028	0.248	0.587	0.515	0.322	0.322
2009	0.055	0.493	1.166	1.024	0.640	0.640
2010	0.057	0.505	1.194	1.049	0.656	0.656
2011	0.090	0.801	1.894	1.664	1.041	1.041

Table 6.2: Mid year Stock Biomass and Spawning Stock Biomass (tons). From age 1 all the specimens are mature, so the stock biomass coincide with the SSB.

	MidYear SB / SSB
2000	78183
2001	103588
2002	146993
2003	172860
2004	170213
2005	182150
2006	174702
2007	132326
2008	150551
2009	125542
2010	142541
2011	215050

The exploitation rate (F/(F+M)) is shown in figure 6. 2.

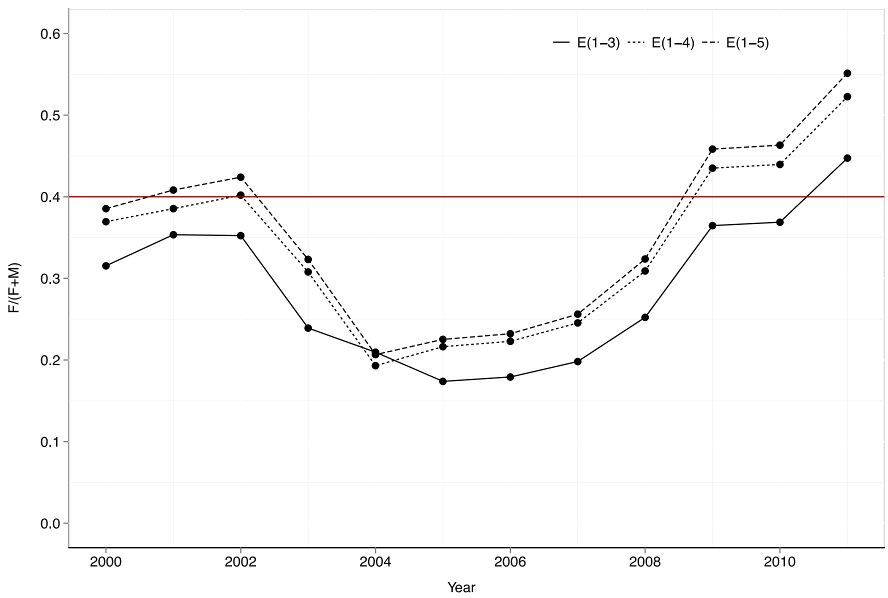

Figure 6.2: Exploitation rate (E = F/(F+M)) for age classes 1-3, 1-4 and 1-5 resulting from ICA analysis.

In figure 6.3 the harvest rate, calculate as the ratio between the catches and the estimates from the ICA model, shows firs a decrease and then an increase starting in 2005. In the last two years the trend looks stable. In 2011 the harvest rate is equal to 0.24. The harvest rate calculated on the acoustic biomass estimates shows instead a fluctuation around a value of 0.1.

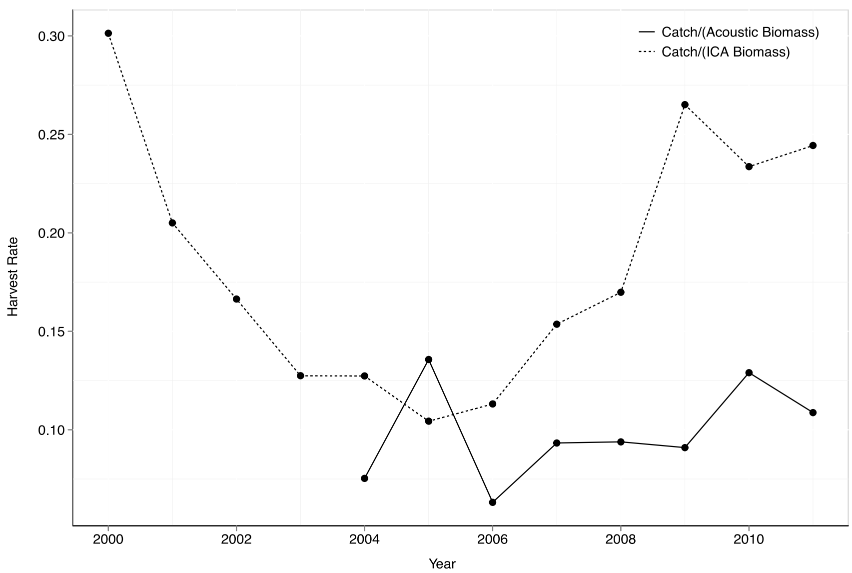

Figure 6.3: Harvest rate estimates (C/B) obtained from the mid year ICA biomass (dashed line) and the acoustic biomass (full line).

The trend in biomass relatively to the proposed reference points is illustrated in figure 6.4.

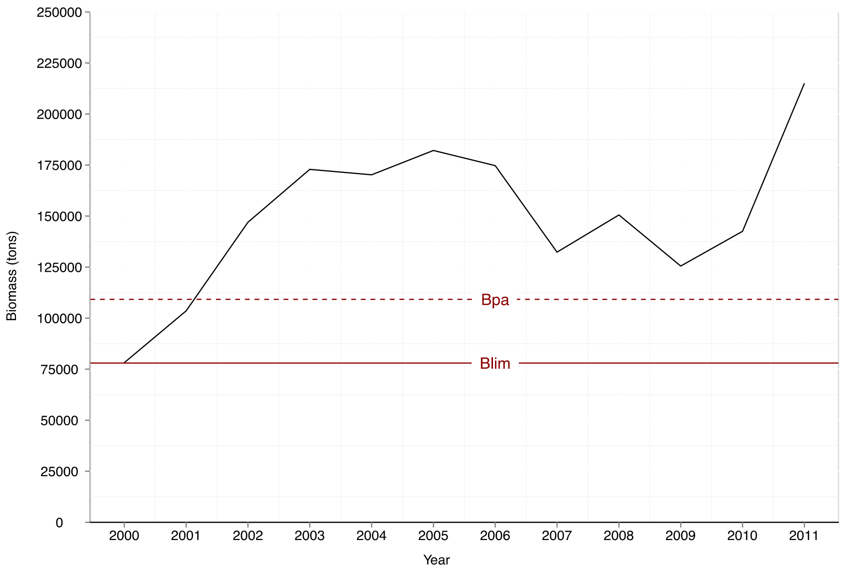

Figure 6.4: Mid-year stock biomass from the ICA analysis with the relative reference points (B_{lim} and B_{pa}).

6.2 Virtual Population Analysis

VPA was carried out applying the Laurec-Shepherd tuning with the acoustic survey index. This tuning procedure derives estimates of fishing mortality at age in the final year from an analysis of the logarithms of fleet catchabilities.

The software used for the analysis is the Lowestoft VPA software (Darby and Flatman, Version 3.1).

6.2.1 Model assumptions

- Tuning method: Laurec-Shepherd
- Tuning index: Acoustic Survey
- Ages 1 to 6+
- Oldest age F = 1.300*average of 2 younger ages
- M vector estimated using Gislason's equation (Gislason *et al.*, 2010):

Age1	Age2	Age3	Age4	Age5	Age6
1.10	0.76	0.62	0.56	0.52	0.50

- Maturity at age:

Age1	Age2	Age3	Age4	Age5	Age6
1	1	1	1	1	1

- Shrinkage applied

6.2.2 Results

VPA estimations of mid-year stock biomass, spawning stock biomass and trend in F by age are show in figures 6.5 and 6.6. The results are given in tables 6.4 and 6.5.
The biomass increases constantly since the beginning of the time series from about 66000 tons up to 483000 tons in 2011.

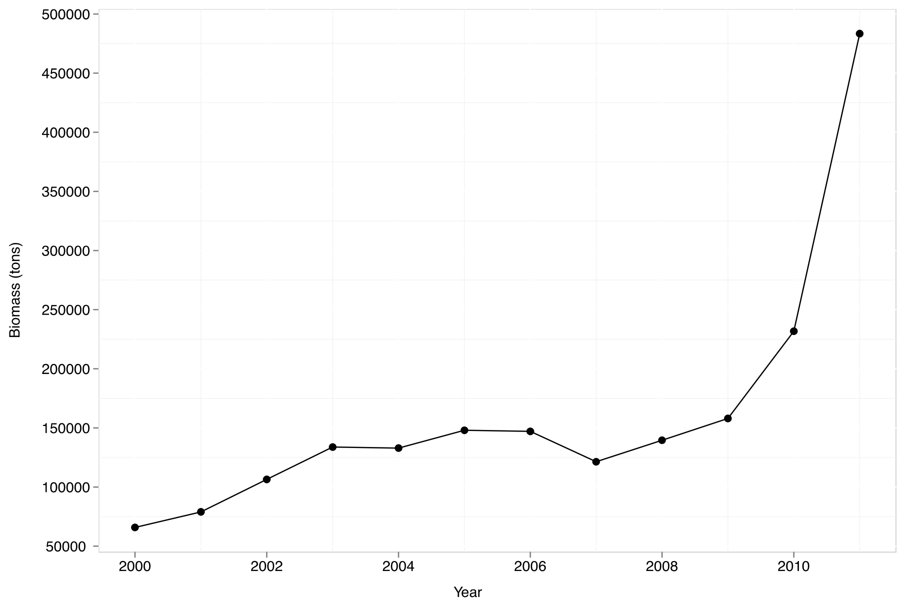

Figure 6.5: Mid-year biomass and mid-year SSB estimated by the means of the Laurec-Shepherd VPA.

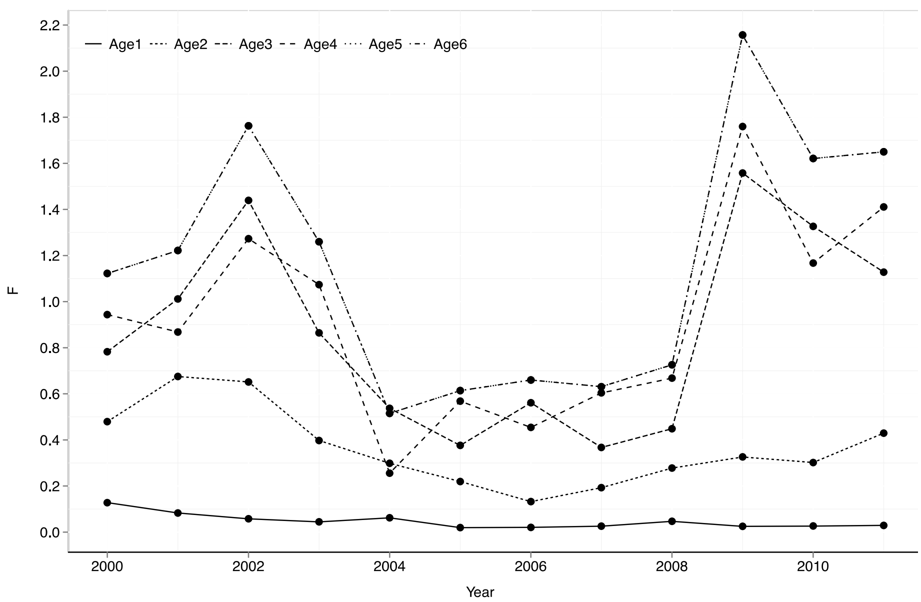

Figure 6.6: F by age estimated by the means of the Laurec-Shepherd VPA.

Table 6.4: Estimated numbers at age (in thousands).

	Age1	Age2	Age3	Age4	Age5	Age6
2000	3091860	689320	229880	106640	67880	75490
2001	4242330	905730	199670	56540	23710	23700
2002	6002190	1299690	215660	39060	13560	11660
2003	7469620	1886000	316770	27510	6250	3510
2004	6257190	2378110	592730	71810	5370	3280
2005	6770840	1957660	825170	186350	31770	7080
2006	5633020	2210150	735070	304810	60300	1410
2007	4934090	1836970	905560	225600	110560	3200
2008	6530140	1600570	708450	337440	70450	59240
2009	8497430	2074000	566950	243360	98820	48590
2010	14959870	2758580	700150	64210	23920	1300
2011	37250640	4851040	953850	99970	11410	5170

Table 6.5: Estimated F at age.

	Age1	Age2	Age3	Age4	Age5	Age6
2000	0.1278	0.4791	0.7825	0.9438	1.1221	1.1221
2001	0.0830	0.6750	1.0115	0.8682	1.2218	1.2218
2002	0.0577	0.6517	1.4391	1.2730	1.7628	1.7628
2003	0.0445	0.3975	0.8641	1.0736	1.2595	1.2595
2004	0.0620	0.2985	0.5371	0.2557	0.5153	0.5153
2005	0.0196	0.2195	0.3759	0.5683	0.6138	0.6138
2006	0.0205	0.1323	0.5612	0.4541	0.6599	0.6599
2007	0.0258	0.1928	0.3672	0.6038	0.6311	0.6311
2008	0.0469	0.2778	0.4486	0.6680	0.7258	0.7258
2009	0.0250	0.3259	1.5581	1.7597	2.1566	2.1566
2010	0.0262	0.3020	1.3264	1.1673	1.6209	1.6209
2011	0.0291	0.4294	1.1278	1.4105	1.6499	1.6499

6.3 Robustness analysis

6.3.1 ICA

The diagnostic graph of the index SSQ against reference age F (age 2) from a separable VPA is plotted in figure 6.7. The curves should be U-shaped, with minima fairly close to each other on *x*-axis (Needle, 2000).

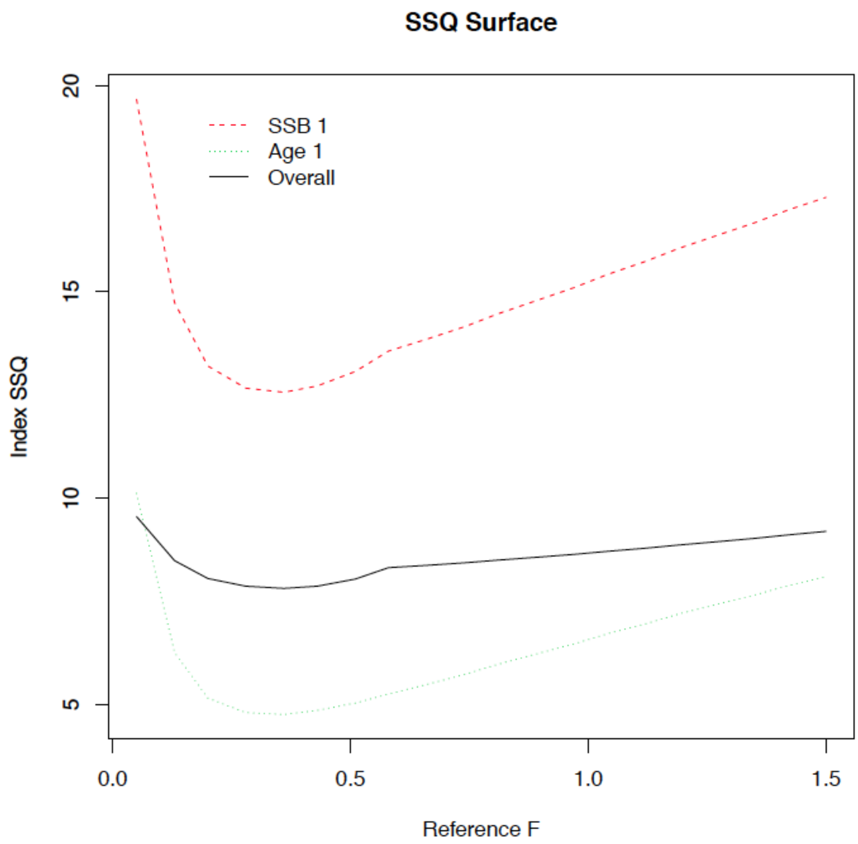

Figure 6.7: SSQ surface plot.

The marginal totals of residuals between the catch and the separable model are overall small, as well as reasonably trend-free in the separable period (2005-2011), but for a small degree of year effect (see figure 6.8).

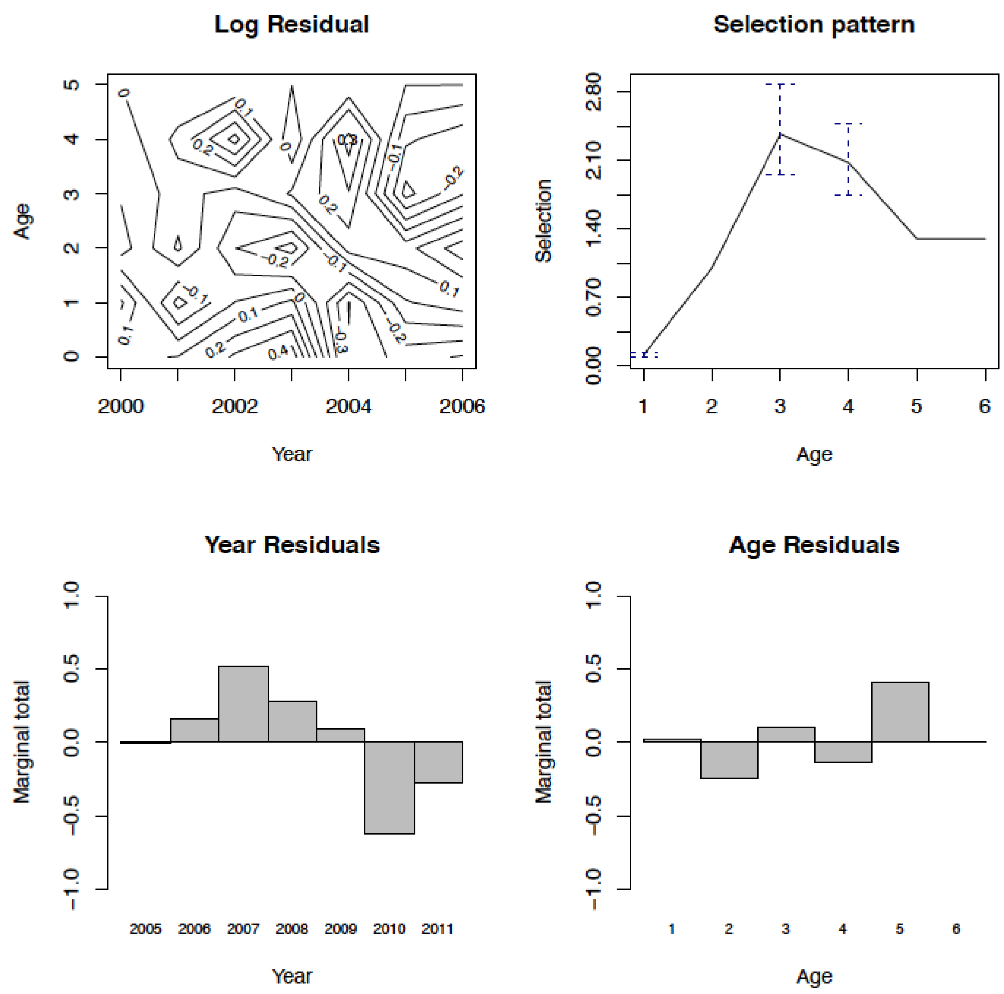

Figure 6.8: Diagnostics: log-residual contour plot (top-left); fitted selection pattern (top-right); year residuals for the catches (bottom-left); age residuals for the catches (bottom-right).

The diagnostics tables for the final run are given below (tables 6.6).

Table 6.6: Parameters estimates for the ICA run.

Sep model : F by year		Maximum Likelh. Estimate	CV %	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
1	2005	0.1413	27	0.0832	0.2399	0.1078	0.1851	0.1465
2	2006	0.1475	25	0.0896	0.2429	0.1144	0.1903	0.1524
3	2007	0.1704	23	0.1066	0.2723	0.1342	0.2164	0.1753
4	2008	0.2479	22	0.1592	0.3861	0.1978	0.3108	0.2543
5	2009	0.4925	19	0.3329	0.7286	0.4033	0.6015	0.5025
6	2010	0.5046	21	0.3308	0.7697	0.4068	0.6259	0.5165
7	2011	0.8005	31	0.4308	1.4873	0.5835	1.098	0.8415
Separable Model: Selection (S) by age								
8	1	0.1125	22	0.0721	0.1754	0.0897	0.1411	0.1154
	2	1	Fixed: Reference Age					
9	3	2.3665	19	1.6212	3.4542	1.9512	2.8701	2.4109
10	4	2.0783	17	1.4806	2.9173	1.7482	2.4709	2.1097

	5	1.3	Fied: Last True Age

Sep model: Populations in year 2011

11	1	16830449	41	7497944	37778891	11141297	25424689	18325263
12	2	2835492	28	1620617	4961082	2131451	3772085	2953366
13	3	510628	24	313368	832061	398030	655079	526721
14	4	102722	27	59533	177243	77767	135686	106778
15	5	19189	30	10495	35087	14104	26108	20121

Sep model: populations at age

16	2005	94555	42	41047	217818	61771	144740	103526
17	2006	149406	33	77887	286597	107159	208308	157890
18	2007	170818	28	97770	298443	128498	227076	177882
19	2008	146450	26	86413	248199	111892	191683	151852
20	2009	125006	25	76415	204495	97246	160689	129010
21	2010	49644	27	28814	85530	37612	65524	51593

Medits

22	1Q	0.00006	21	5.15E-05	1.19E-04	6.31E-05	9.67E-05	7.99E-05

Age-structured index catchabilities (Acoustic Survey)

Linear model fitted. Slopes at age

23	1Q	0.9444	34	0.6754	2.6540	0.9444	1.8980	1.4230
24	2Q	4.1430	35	2.9570	11.7200	4.1430	8.3650	6.2610
25	3Q	6.0280	36	4.2540	17.6500	6.0280	12.4600	9.2560
26	4Q	2.3580	38	1.6310	7.3480	2.3580	5.0820	3.7260
27	5Q	0.3224	40	0.2193	1.0570	0.3224	0.7189	0.5217
28	6Q	0.5987	51	0.3664	2.7210	0.5987	1.6650	1.1380

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted

Variance	0.1487
Skewness test stat.	0.5036
Kurtosis test statistic	-0.9945
Partial chi-square	0.1795
Significance in fit	0
Degrees of freedom	14

DISTRIBUTION STATISTICS FOR MEDITS

Linear catchability relationship assumed

Last age is a plus-group

Variance	0.1274
Skewness test stat.	-0.4913
Kurtosis test statistic	-0.8465
Partial chi-square	0.6374
Significance in fit	0
Number of observations	12
Degrees of freedom	11
Weight in the analysis	0.3

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES (Acoustic Survey)

Linear catchability relationship assumed

Age	1	2	3	4	5	6
Variance	0.0903	0.0134	0.1381	0.1753	0.3037	0.2461
Skewness test stat.	-0.6693	-0.2191	0.4479	0.8021	0.4657	-0.2745
Kurtosis test statisti	-0.3183	-0.6698	-0.482	-0.1637	-0.0758	-0.5743
Partial chi-square	0.0423	0.0062	0.069	0.1063	0.2483	0.0791
Significance in fit	0	0	0	0	0.0001	0.0058
Number of observations	8	8	8	8	8	4
Degrees of freedom	7	7	7	7	7	3
Weight in the analysis	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667

Unweighted Statistics

Variance	SSQ	Data	Parameters	d.f.	Variance
Total for model	41.4587	91	28	63	0.658
Catches at age	2.0823	35	21	14	0.149
Medits	4.6727	12	1	11	0.425
Acoustic Survey	34.7037	44	6	38	0.913

Weighted Statistics

Variance	SSQ	Data	Parameters	d.f.	Variance
Total for model	3.4669	91	28	63	0.055
Catches at age	2.0823	35	21	14	0.149
Medits	0.4205	12	1	11	0.038
Echo West + East TrGi SepNov Commercia	0.964	44	6	38	0.025

The retrospective analysis (figure 6.9) shows some degree of variation on the estimates for all the variables, a little bit less for the case of F_{bar}. For the 2009-2010 estimates this trend is stronger. Future investigations will aim to solve this problem.

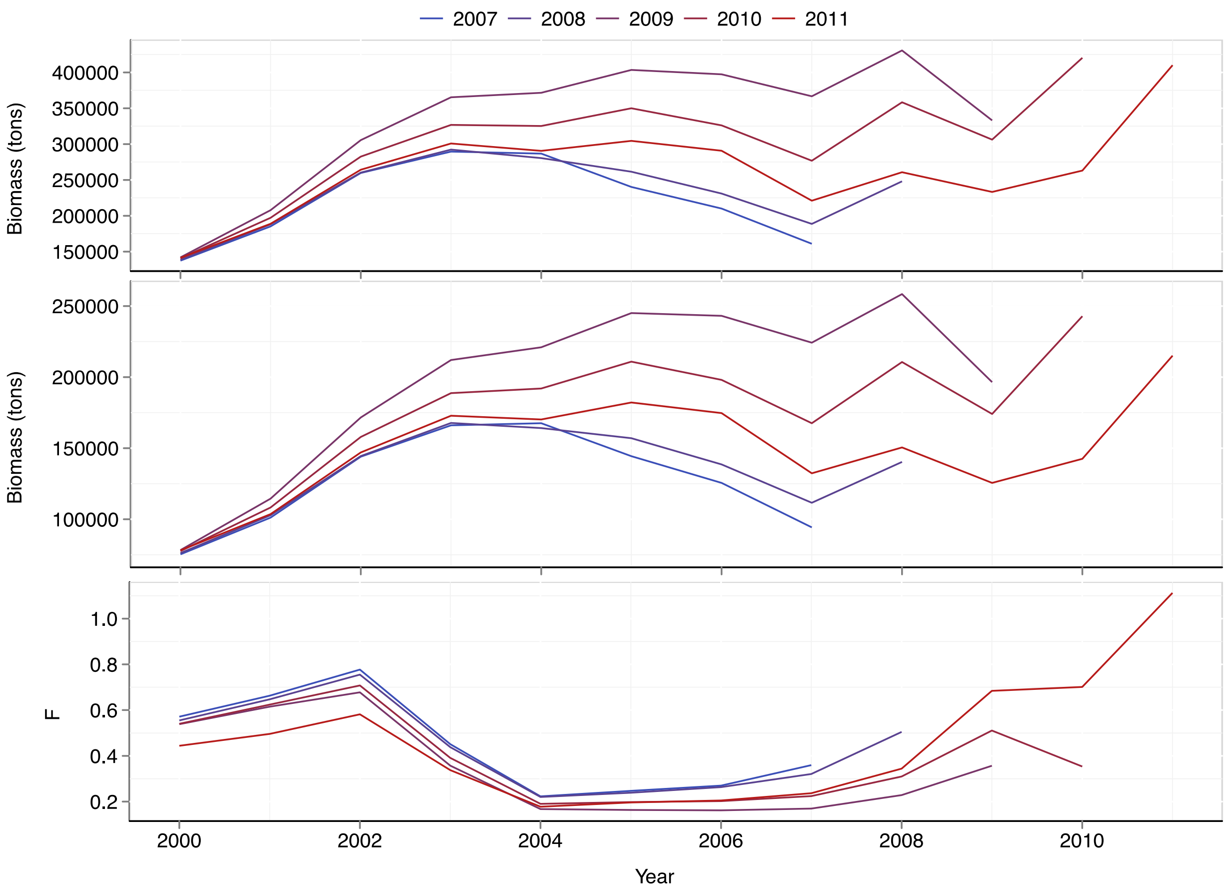

Figure 6.9: ICA Retrospective analysis for total stock biomass at the beginning of the year (on top), mid year SSB (in the middle) and F (at the bottom).

The fitting of the model estimates with the acoustic surveys is shown in figure 6.10. The predicted numbers at age fit quite well the observed data, except for some disagreement in the 2009 estimates.

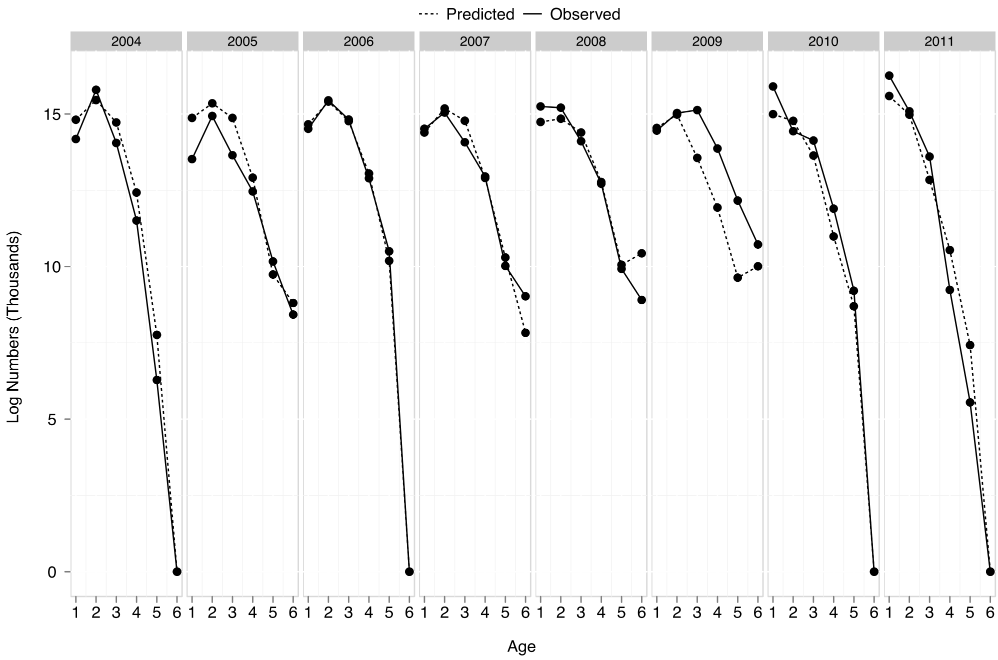

Figure 6.10: Predicted VS Expected log numbers at age for the acoustic survey.

6.3.2 VPA

The summary statistic for the VPA run is shown in table 6.7.

Table 6.7: Summary statistic by age for the Laurec-Shepherd VPA.

SUMMARY STATISTICS FOR AGE 1

Fleet	Pred. Log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	-0.65	0.595	0.5195	0.0293	1.07E-	8.26E-	-0.655	0.198

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.029	0.595	0	0.595	0

SUMMARY STATISTICS FOR AGE 2

Fleet	Pred. Log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	0.94	0.563	2.5477	0.8704	-1.67E-	5.62E-	0.935	0.188

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
0.429	0.563	0	0.563	0

SUMMARY STATISTICS FOR AGE 3

Fleet	Pred. Log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	1.3	0.8	3.6679	2.3083	3.90E-	1.25E-	1.3	0.267

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
1.128	0.8	0	0.8	0

SUMMARY STATISTICS FOR AGE 4

Fleet	Pred. Log q	se (log q)	Partial F	Raised F	Slope	se Slope	Intrcpt	se Intrcpt
1	0.81	1.166	2.2485	******	-8.34E-	1.80E-	0.81	0.389

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall)	Variance ratio
1.411	1.17	0	1.17	0

The restrospective analysis (figure 6.11) shows lower variability on the estimates than the VPA, with the only exceptions of the estimates including up to 2009, which show a larger divergence respect to the other years.

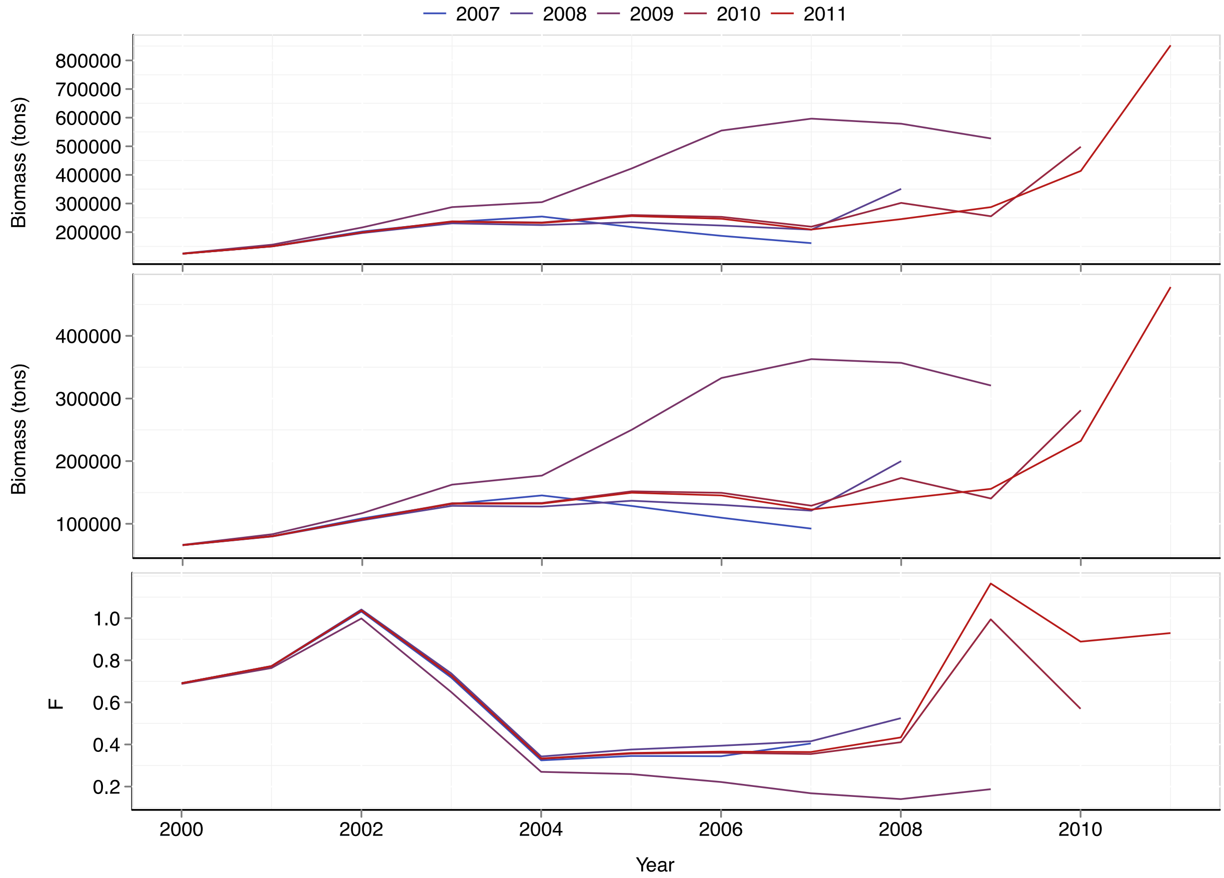

Figure 6.11: VPA Retrospective analysis for respectively total stock biomass at beginning of the year (on top), mid year SSB (in the middle) and F (at the bottom).

The residuals for ln(q) (figure 6.12) are reasonably trend free with some high values.

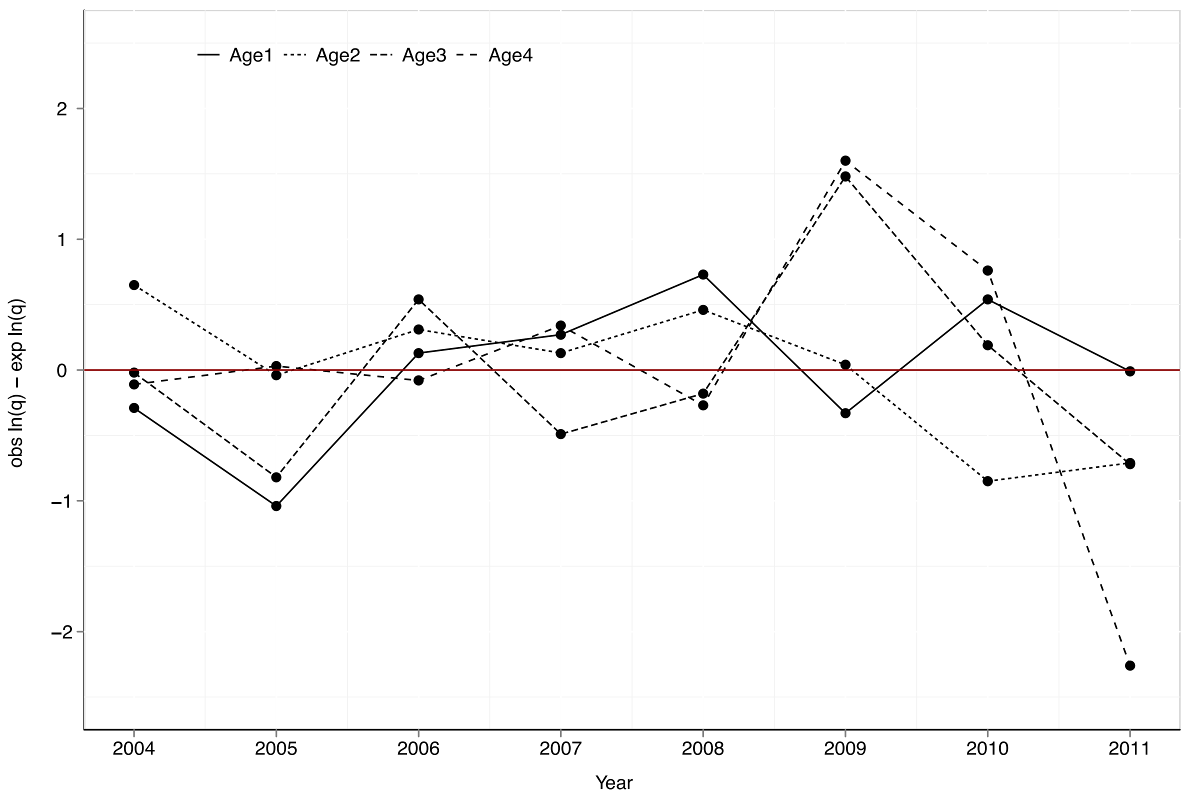

Figure 6.12: Observed log(q) – Expexted log(q) by age estimated by VPA analysis.

6.4 Assessment quality

The separable VPA performed well with the data available, even if the analysis revealed some uncertainty in the retrospective analysis, with variable results for previous years. Nevertheless, ICA improved the parameters estimates respect to the Laurec-Shepherd VPA, which in general has high standard error.
The comparison between the resulting biomasses from the two models is shown in figure 6.13.

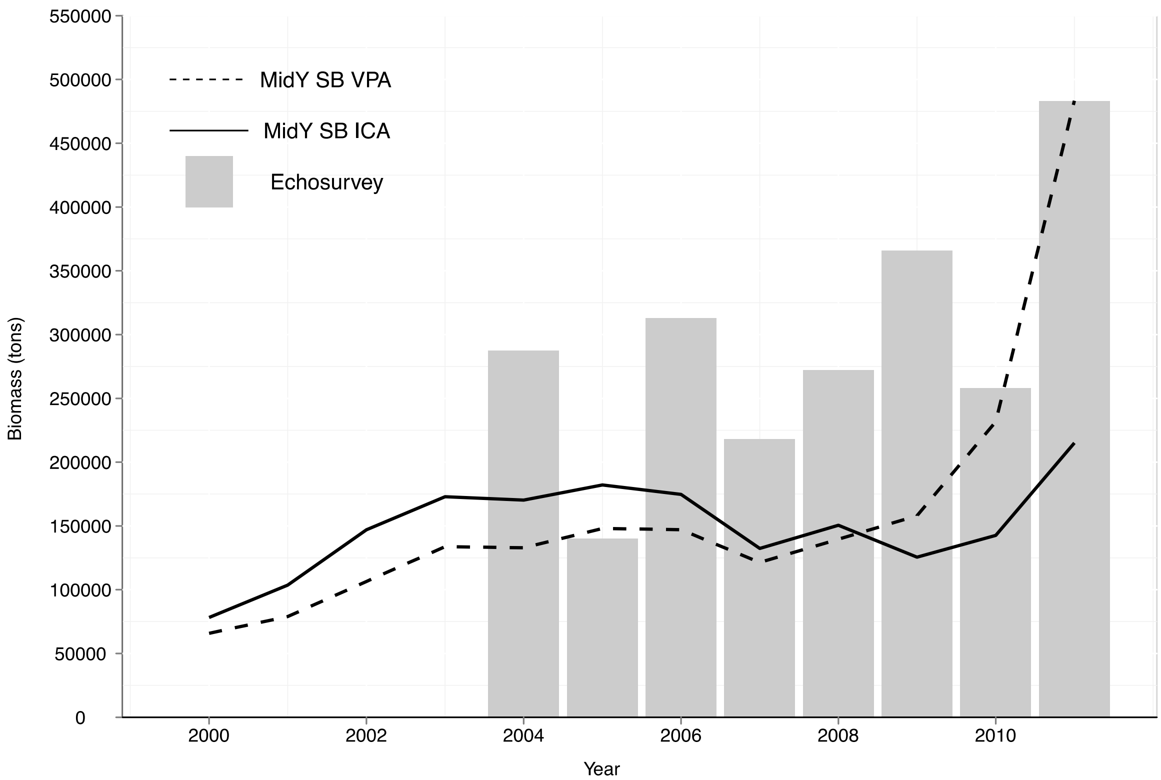

Figure 6.13: Mid-year Stock Biomass from VPA (dashed line) and ICA (full line); acoustic biomass estimates are shown as well in the form of background bars.

An ICA run was performed without the bottom trawl survey to test how much the inclusion of this index influences the model results. Despite a slight increase in the SSQ minimization, the CVs of the parameters estimations got worst. Besides, the resulting trend in biomass and F are almost identical, which was expected due to the really low weight gave to the index in the model.
ICA with absolute catchability model for the acoustic survey was attempted: the SSQ and the CVs were really high, the residuals showed clear trends in ages and years with high values and the fitting with the acoustic survey got much worst.
In the present assessment there is improved coherence between the biomass estimated from the model and the survey data respect to last year assessment, although absolute biomass levels for the acoustic survey remain about double the estimates of the assessment model.

7 Stock predictions

N/A

7.1 Short term predictions

N/A

7.2 Medium term predictions

N/A

7.3 Long term predictions

N/A

8 Draft scientific advice

This year we will use the already approve reference point for F (Patterson) and another set of reference points proposed for biomass.
The assessment shows a steep increase in the total biomass trend starting in 2009 and in the recruitment since 2007. The exploitation rate ($E_{(1-4)}$ = 0.52) is higher than the reference point of E = 0.4 from Patterson. On the other hand the 2011 total biomass (215050 tons) is above of both the proposed B_{lim} (78000 tons) and B_{pa} (109200 tons) reference points.
The acoustic surveys in 2011 estimated a really high biomass (about 500000 tons), the highest of the time series up to now.
It should be noted that Adriatic small pelagic fishery is multispecies and effort on anchovy cannot be separated from effort on sardine, so that most of the management decision have to be taken considering both species.
Although F is higher than the RP, the SSB shows an increasing trend, so the current state of the fishery seems to be sustainable. On the overall, the suggestion is not to increase the fishing mortality.

Table 8.1: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
[2000-2011]		[2000-2011]	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality	X	Intermediate abundance
X	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table 8.2: Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
[2000-2011]		[2000-2011]	
[78183 tons-215050 tons]		[3276600 – 16830000 thousands]	
	Stable	X	Stable
X	Increasing		Increasing
	Decreasing		Decreasing

The trend in recruitment shows a stable pattern but in the last year it increased.

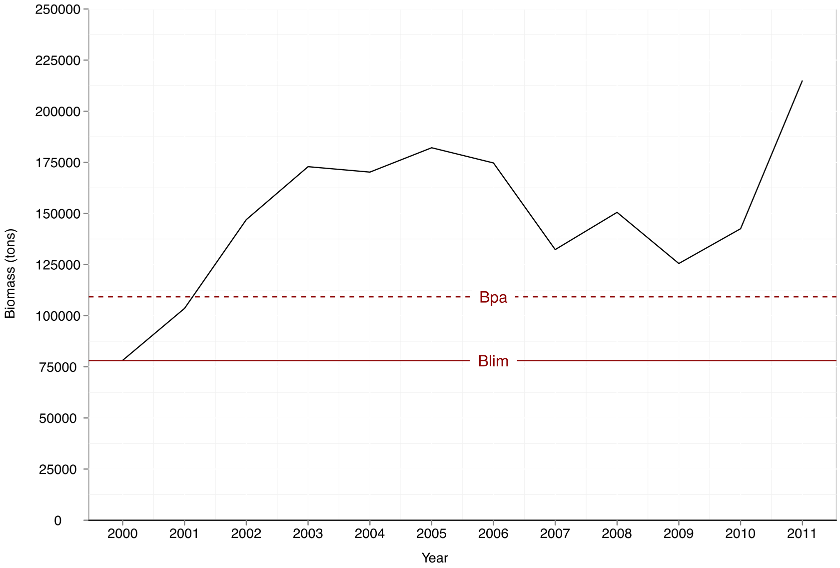

Figure 8.1: Mid-year stock biomass and proposed reference points.

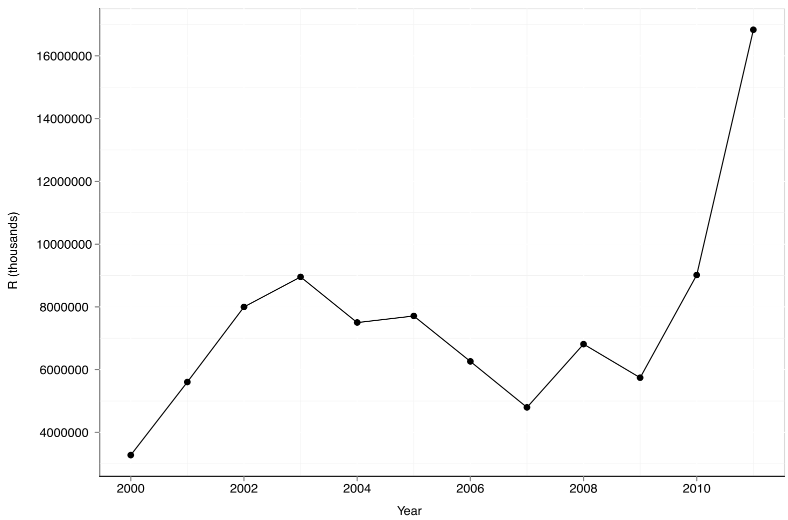

Figure 8.2. Recruitment estimates (in thousands).

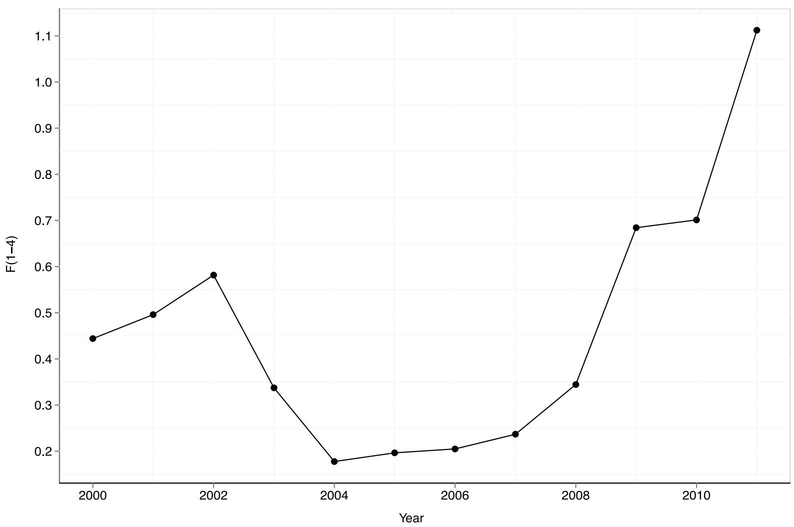

Figure 8.3: $F_{bar(1\text{-}4)}$ estimates.

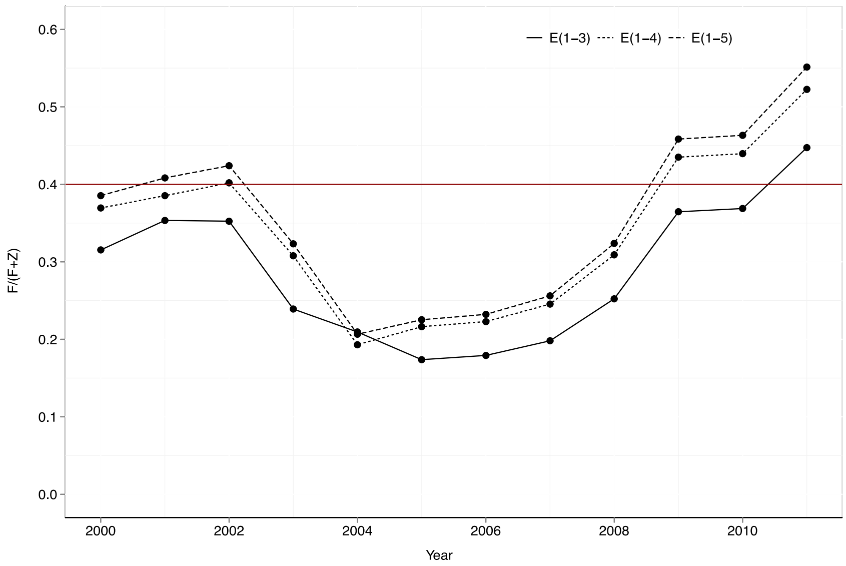

Figure 8.4: Exploitation rate (F/Z).

9 Bibliography

Darby, C. D. and Flatman, S. (1994). Virtual Population Analysis: Version 3.1 (Windows/Dos) user guide. Info. *Tech. Ser. MAFF Direct. Fish. Res*., Lowestoft.

Gislason, H., Daan, N., Rice, J. C., and Pope, J. G. (2010*).* Size, growth, temperature and the natural mortality of marine fish*. Fish and Fisheries*, 11(2):149–158.

MEDIAS, Report of 5th meeting for Mediterranean Acoustic Surveys (MEDIAS) in the framework of European Data Collection Framework (DCF) Sliema, Malta, 20-22 March 2012 Steering Committee Report.

MEDITS Working Group (April 2012). MEDITS-Handbook, Revision n. 6: 92 pp.

Patterson, K. R. and Melvin, G. D. (1996). Integrated catch at age analysis - version 1.2. *Technical Report 58*, The Scottish Office - Agriculture, Environment and Fisheries Department.

Patterson, K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. *Reviews in Fish Biology and Fisheries*, 2:321–338.

Sbrana M., De Ranieri S., Ligas A., Reale B., Rossetti I. and Sartor P. (2010), Comparison of trawl survey and commercial data on small pelagics from the FAO geographic sub-area 9 (Western Mediterranean Sea). *Rapp. Comm. int. Mer Médit., 39*

Sinovcic G. (1984), Summary of biological parameters of sardine (*Sardine pilchardus* Walb) from the Central Adriatic. *FAO Fishery report 290*

Tinti F., Di Nunno C., Guarniero I., Scapolatempo M. & Vallisneri M. (2002b). Population structure of the Adriatic *Sardina pilchardus* (Walbaum, 1972) based on molecular and morphometric marker analysis. *Biologia Marina Mediterranea* **9**, 105–111.

Tinti F., Di Nunno C., Guarniero I., Talenti M., Tommasini S., Fabbri E. & Piccinetti C. (2002°). Mitochondrial DNA sequence variation suggests the lack of genetic heterogeneity in the Adriatic and Ionian stocks of *Sardina pilchardus*. *Marine Biotechnology* **4**, 163–172.

Stock Assessment Form

Anchovy in GSA 17 (Northern Adriatic)

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1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Engraulis encrasicolus	European anchovy	35 - Herrings, sardines, anchovies
Geographical sub-area:		
GSA 17		
Stock assessment method: (direct, indirect, combined, none)		
Combined		
Authors: Carpi P. (1), (*in alphabetical order)* Angelini S. (1), Belardinelli A. (1), Biagiotti I. (1), Campanella F. (1), Canduci G. (1), Cingolani N. (1), Čikeš Keč V.(2), Colella S. (1), Croci C. (1), De Felice A. (1), Donato F.(1), Leonori I. (1), Martinelli M. (1), Malavolti S. (1), Modic T. (3), Panfili M. (1), Pengal P. (3), Santojanni A. (1), Tičina V. (2), Vasapollo C. (1), Zorica B. (2), Arneri E (4).		
Affiliation: (1) CNR-ISMAR (Ancona, Italy), (2) Institute of Oceanography and Fisheries (Split, Croatia), (3) Fisheries Research Institute of Slovenia (Ljubjana, Slovenia), (4) FAO-Adriamed (Rome, Italy)		

2 Stock identification and biological information.

2.1 Stock unit

Anchovy stock is shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia) and it constitutes a unique stock.

Many studies have been carried out regarding the presence of a unique stock or the presence of different sub populations living in the Adriatic Sea (GSA 17 and GSA 18). This has several implications for the management, i.e. differences in the growth features between subpopulations imply the necessity of ad hoc strategies in the management. The hypothesis of two distinct populations claims the evidence of morphometric differences between northern and southern Adriatic anchovy, such as color and length, and some variability in their genetic structure (Bembo et al., 1996). Nevertheless, many authors warns against the use of morphological data in studies on population structure (Tudela, 1999) and, a recent study from Magoulas et al. (2006), revealed the presence of two different clades in the Mediterranean, one of those is characterized by a high frequency in the Adriatic Sea (higher than 85%) with a low nucleotide diversity (around 1%).

2.2 Growth and maturity

Table 2.2.1: Maximum size, size at first maturity and size at recruitment.

	Somatic magnitude measured (LH, LC, etc)*			TL		Units*	cm
Sex	Fem	Mal	Both	Unsexed			
Maximum size observed			18		Reproduction season		April - October
Size at first maturity			8		Reproduction areas		Mainly western Adriatic.
Recruitment size			9		Nursery areas		Mainly along western Adriatic coast, River Po delta, Manfredonia Gulf

Table 2.2.2: Growth and length weight model parameters.

			Sex			
		Units	female	male	both	unsexed
Growth model	L∞	Cm			19.4	
	K	y^{-1}			0.57	
	t0	y			-0.5	
	Data source	Sinovcic, 2000				
Length weight relationship	a				0.004	
	b				3.0	

	Age0	Age1	Age2	Age3	Age4	Age5			
M (vector by age) Gislason *et al*, 2010	2.36	1.10	0.81	0.69	0.64	0.61			

sex ratio (% females/total)	63.2

3 Fisheries information

3.1 Description of the fleet

Table 3.1.1: Description of operational units in the stock.

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	Italy	17	Pelagic trawlers	Trawls	35 - Herrings, sardines, anchovies	Engraulis encrasicolus
Operational Unit 2	Italy	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Engraulis encrasicolus
Operational Unit 3	Croatia	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Engraulis encrasicolus
Operational Unit 4	Slovenia	17	Purse Seiners	Surrounding Nets	35 - Herrings, sardines, anchovies	Engraulis encrasicolus
Operational Unit 5	Slovenia	17	Pelagic trawlers	Trawls	35 - Herrings, sardines, anchovies	Engraulis encrasicolus

Table 3.1.2: Catch, bycatch, discards and effort by operational unit

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
1	84	tons	17200				
2	19	tons	2500				
3	NA	tons	13600				
4	5	tons	124				
5	1						
Total	122						

Table 3.1.3: Catches as used in the assessment.

Classification (age, length, recruit/spawner)	Catch (tn)
2000	29036
2001	28280
2002	23467
2003	25016
2004	31280
2005	42296
2006	43090
2007	47055
2008	41151
2009	44280
2010	39639
2011	35058
Average	35804

3.2 Historical trends

In figure 3.1 the trend in landings for Italy and Croatia are shown. From 2002 the trend is increasing with a maximum of 47055 tons in 2007. The Slovenian catches are included in the total landings but are not shown here since the quantities are really low (less than 150 tons in 2011):

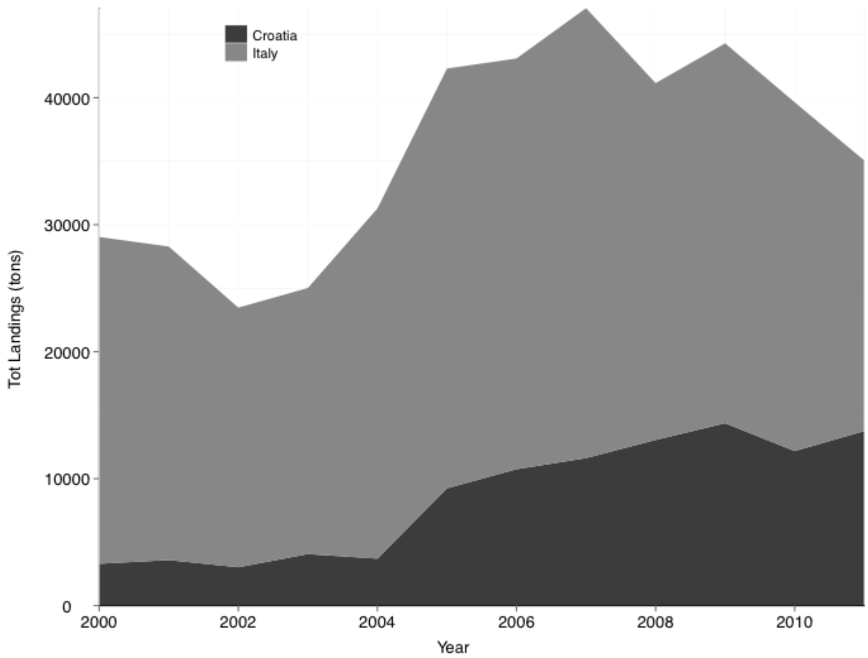


Figure 3.1: Total landings (in tons) by country for GSA 17 from 2000 to 2011.

The trend of the cohorts in the catches is shown in figure 3.2. Each plot represents the number of fish of each age born in the same year. Age 1 can be identified as the first fully recruited age.

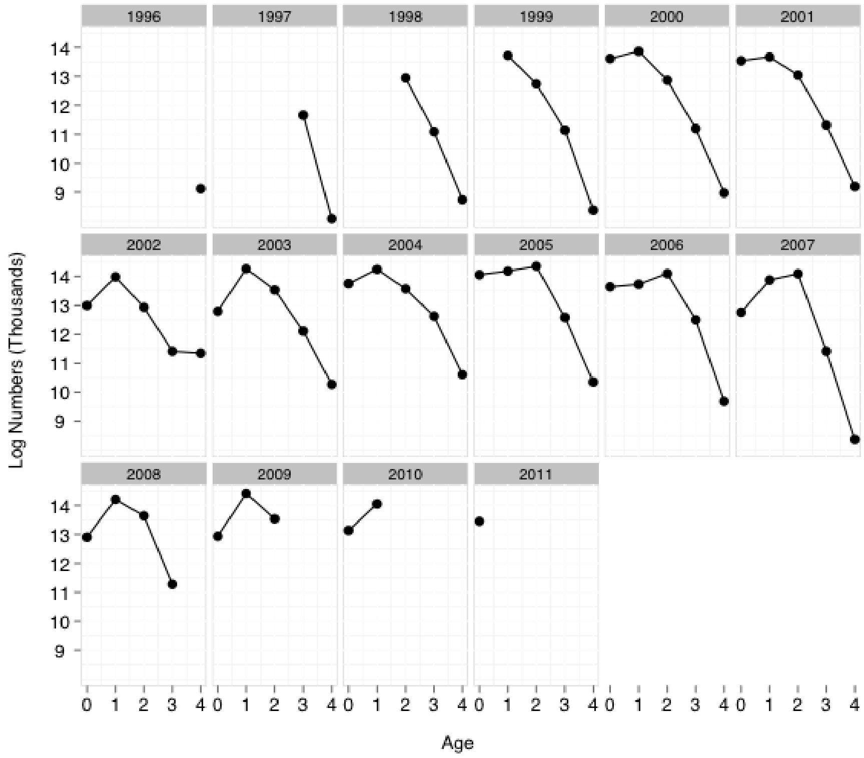


Figure 3.2.2: Log numbers at age (thousands) of the catch at age used in the assessment.

The mean weight at age (in kg) as obtained by sampling of commercial catches is given in figure 3.3.

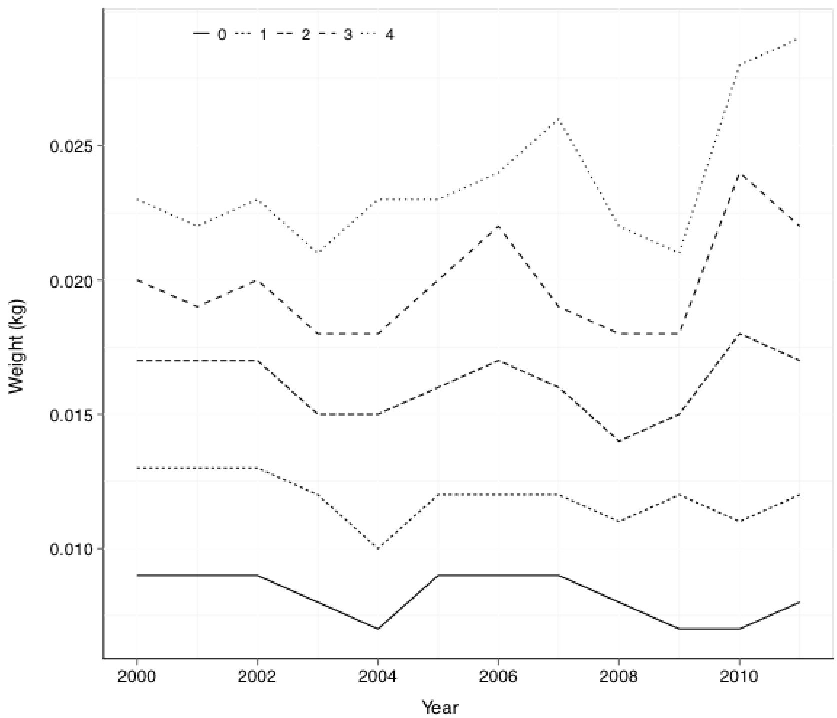


Figure 3.2.3: Mean weight at age (kg) in the catches.

3.3 Management regulations

A closure period is observed from the Italian pelagic trawlers on August, and from 15th December to 15th January from the Croatian purse seiners. In 2011 a closure period of 60 days (August and September) was endorsed by the Italian fleet.

3.4 Reference points

The present assessment has been considered as a benchmark assessment for biomass reference points. Up to now, the Patterson's reference point of E=0.4 has been adopted as fishing mortality reference point.

The reference points that were proposed during the working group are B_{lim} and B_{pa}. The criterion adopted for B_{lim} has been the minimum mid-year biomass value of the assessed time series, which is of the same magnitude of the minimum value observed since 1976, so it seemed to be reasonable. B_{pa} has been established in relation to Blim using an estimate or assumption on the coefficient of variance of the estimates (see general sections), and assuming that the confidence intervals for the estimate of the assessment model are estimate ± 2 * CV * estimate. In this case a CV of 20 % has been assumed, therefore B_{pa} has been established as 40% above B_{lim}.

Table 3.4: List of reference points.

Criterion	Current value	Units	Reference Point	Trend	Comments
B					
SSB					
F					
Y					
CPUE					
E	0.41		0.4	Stable	Patterson (1992)
Blim	333404	tons	179000	Stable	
Bpa	333404	tons	250600	Stable	

4 Fisheries independent information

4.1 ECHOSURVEY (Acoustic survey)

4.1.1 Brief description of the chosen method and assumptions used

Echosurveys were carried out from 2004 to 2011 for the entire GSA 17. In the western part the acoustic survey was carried out since 1976 in the Northern Adriatic (2/3 of the area) and since 1987 also in the Mid Adriatic (1/3 of the area), and it is in the MEDIAS framework since 2009. The eastern part was covered by Croatian national pelagic monitoring program PELMON. The data from both the surveys have been combined to provide an overall estimate of numbers-at-age.

The survey methods for MEDIAS are given in the MEDIAS handbook (MEDIAS, March 2012).

Western Echosurvey:

- Length frequencies distribution available from 2004 onward (no LFD for Mid Adriatic in 2004, so the proportion of biomass at length in 2004 was assumed equal to the proportion of biomass at length in the 2005 Mid Adriatic survey).
- ALKs available for 2009-2010-2011;
- Numbers at age for 2004 to 2008 were obtained applying the sum of the 2009-2010-2011 ALKs to the numbers at length.

Eastern Echosurvey:

- Length frequencies distribution available from 2009.
- No ALKs available.
- Numbers at length from 2004 to 2008 were obtained applying the length frequency distribution from the 2009 survey to the total biomass.
- Numbers at age were obtained applying commercial ALK from the eastern catches to the eastern echosurvey length distribution.
- 2011 survey covered only the Northern part of the area (about 52% of the total area), so the estimated biomass was raised to the total using an average percentage from previous years (2004-2010).

4.1.2 Spatial distribution of the resources

Acoustic sampling transects and the total area covered are shown in figure 4.1.

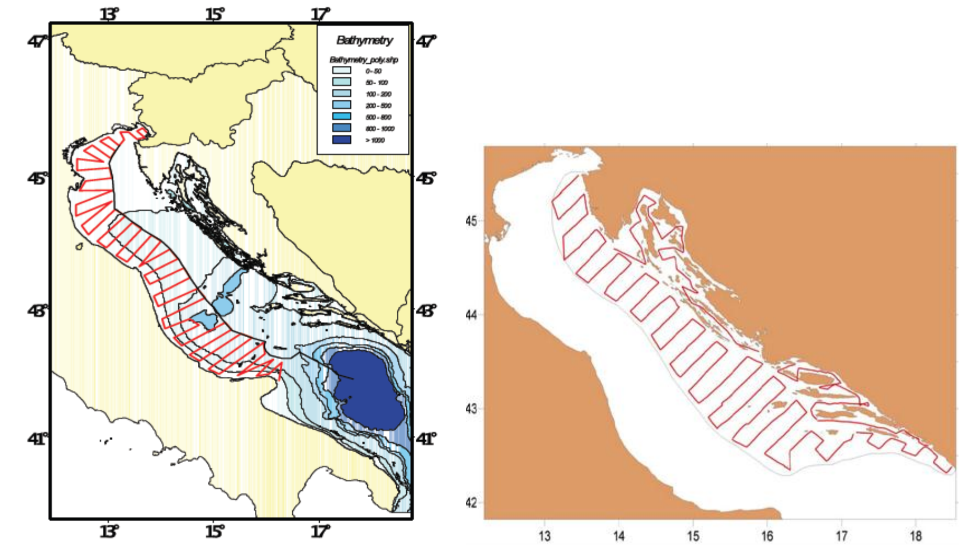


Figure 4.1: Acoustic transects for the western echosurvey (on the left) and the eastern echosurvey (on the right).

4.1.3 Historical trends

Biomass estimates from the two surveys show a much higher occurrence of anchovy on the western side of the Adriatic. In 2008 the western survey contributed to more than 85% of the total estimated biomass.
Pooled total biomass in tons from eastern and western echosurvey (2004-2011) is given in table 4.1 and it is shown in figure 4.2.

Table 4.1: Total biomass (tons) estimated by the acoustic surveys in GSA 17.

	Tons
2004	302130
2005	335312
2006	627226
2007	533525
2008	858497
2009	486373
2010	642184
2011	474920

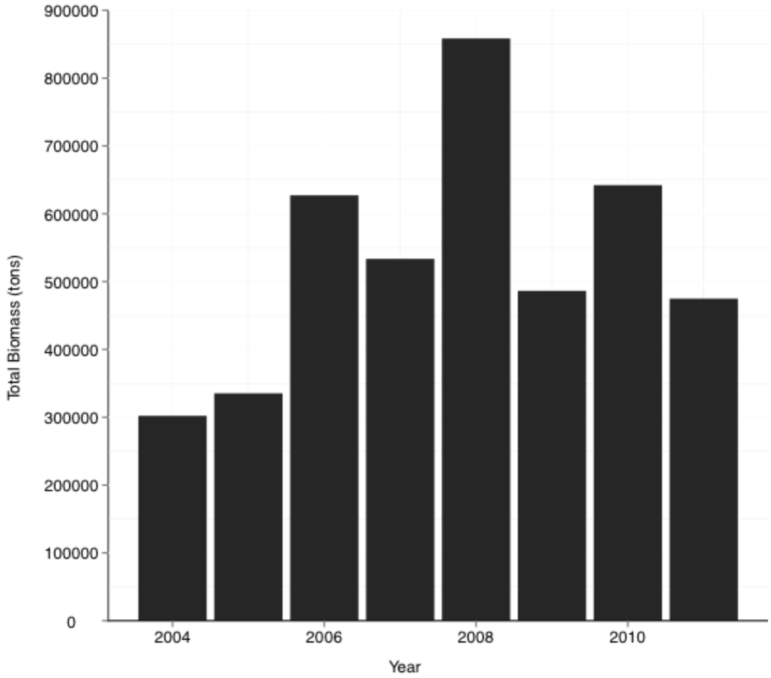


Figure 4.2: Total biomass (tons) estimated from the eastern and western echosurvey.

Figure 4.3 illustrates the proportion by year of each age class from the surveys. In 2008 a higher percentage of age 0 occurred. Age 3 and age 4 are scarcely represented in the estimation.

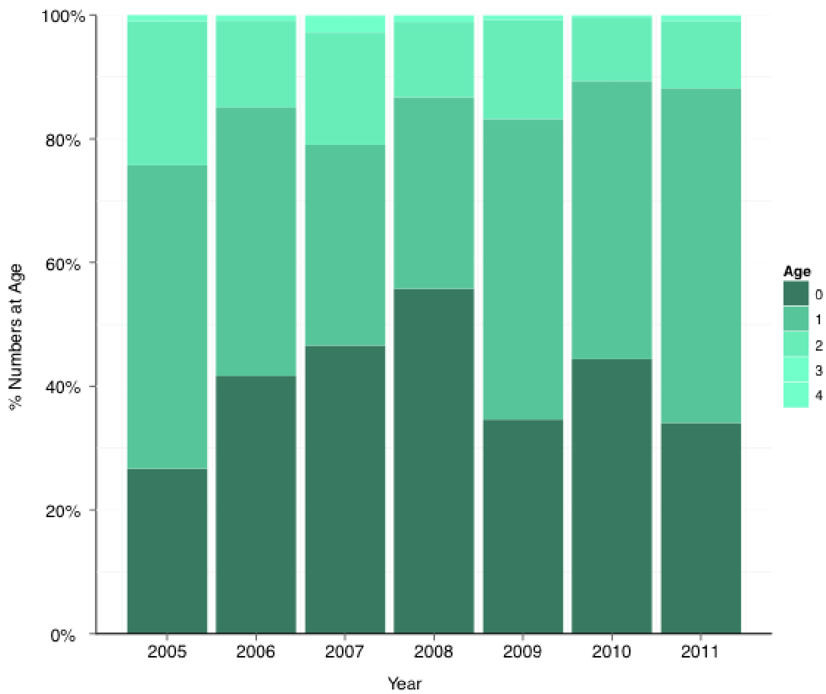


Figure 4.3: Total proportion of age classes for the two surveys.

In figure 4.4 the trend of the cohorts in the acoustic survey is shown. Each plot represents the number of fish of each age born in the same year:

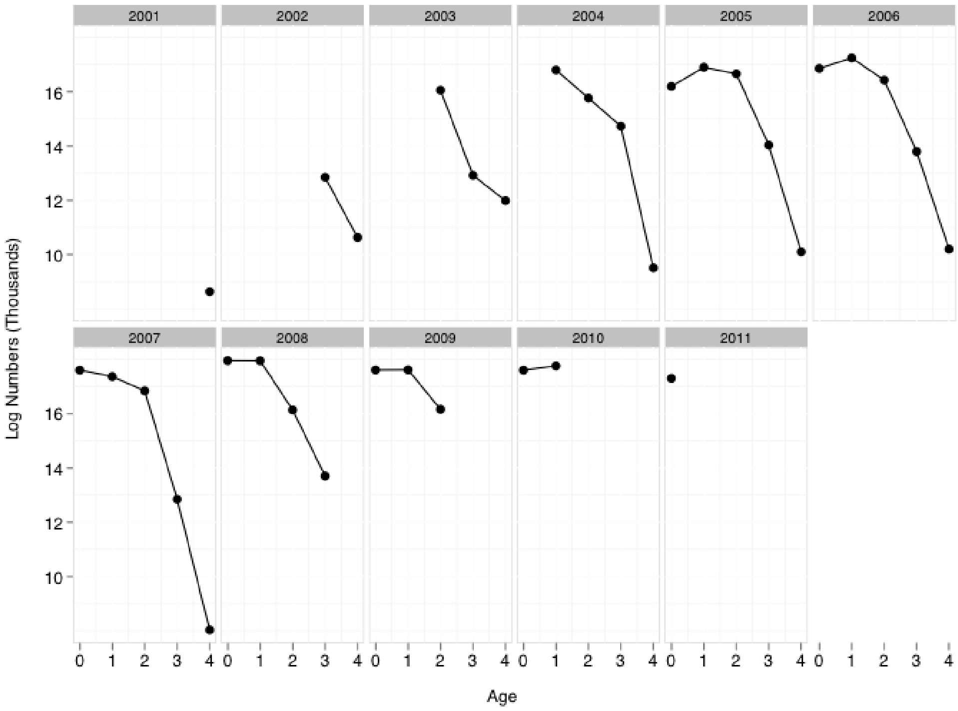


Figure 4.4: Log numbers at age (thousands) of the echosurvey index used in the assessment.

4.2 MEDITS

4.2.1 Brief description of the chosen method and assumptions used

The MEDITS bottom trawl survey started in 1994 and it has been carried out every year since. It takes place during the summer months (June-July) and it provides indices of fish abundance in the deepest part of water column (i.e. within layer up to 3 m above sea bed). Although this survey is targeted to investigate species living near the bottom, the characteristics of the net employed (high vertical opening of the mouth) allow to regularly catch species living in the water column, as small pelagics (Sbrana *et al.,* 2010).
The survey methodology is given in the MEDITS handbook (MEDITS, April 2012).

4.2.2 Spatial distribution of the resources

The spatial distribution of the Medits stations during the 2010 trawl survey is illustrated in figure 4.5.

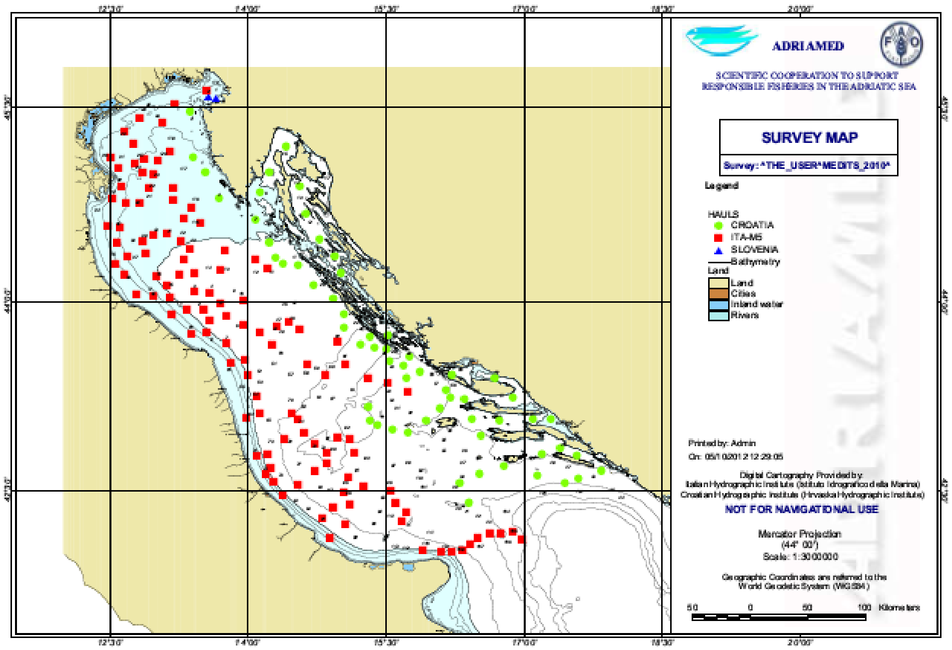


Figure 4.5: Spatial distribution of the MEDITS stations in GSA 17.

4.2.3 Historical trends

The biomass index (kg/km^2) (table 4.2) shows an overall decreasing trend up to 2009, followed by a steep increase in the last couple of years.

Table 4.1: MEDITS index of biomass (kg/km^2) from 2000 to 2011.

MEDITS biomass index	
Year	kg/km^2
2000	37.42
2001	86.00
2002	72.37
2003	71.57
2004	55.00
2005	58.92
2006	56.54
2007	32.27
2008	48.42
2009	27.06
2010	51.77
2011	116.56

The comparison between the acoustic series of total biomass and the trawl survey biomass index shows a general agreement between the two indices (figure 4.6). The only exceptions are 2006 and 2011: in 2006 MEDITS saw a slightly decreasing biomass while acoustic surveys

showed a strong increase and in 2011 acoustic surveys saw a decreasing biomass and MEDITS showed the opposite.
The weight given in the assessment to the MEDITS trawl survey is much lower to the weight given to the acoustic survey (see section 6.1.1).
The 2011 data for both the indices didn't enter in the analysis (due to the split year assumption).

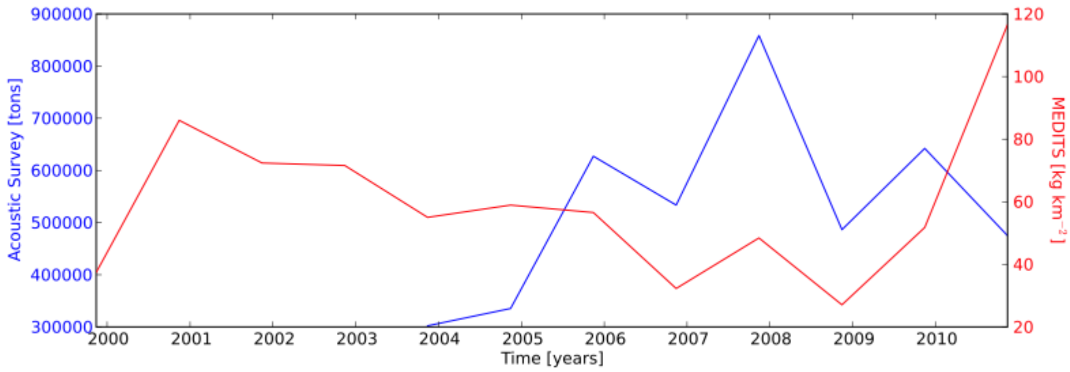


Figure 4.6: Comparison between biomass index from the acoustic survey (axis on the left, blue line) and the bottom trawl survey (axis on the right, red line).

5 Ecological information

N/A

5.1 Protected species potentially affected by the fisheries

N/A

5.2 Environmental indexes

N/A

6 Stock Assessment

Integrated Catch Analysis (ICA) and Virtual Population Analysis (VPA) have been performed from 2000 to 2011.
Acoustic and bottom trawl survey were available for the assessment of anchovy in GSA 17. The weight given to the bottom trawl survey was decided equal to 0.3, in comparison to weight 1 given to the acoustic survey.

6.1 Integrated Catch Analysis

The final assessment of anchovy was carried out by fitting the integrated catch-at age model (ICA) with a separable constraint over a twelve-year period, tuned with the Acoustic survey (2004-2010) and bottom trawl survey biomass index (2000-2011).
ICA was performed using the Patterson's software (ICA, version 4.2 – Patterson and Melvin, 1996).
The model settings are presented in section 6.1.1.

6.1.1 Model assumptions

- Split year assumption
- Ages 0 to 5 (since the software doesn't accept less than 6 age class)
- M vector estimated using Gislason's equation (Gislason *et al.*, 2010):

Age0	Age1	Age2	Age3	Age4	Age5
2.36	1.10	0.81	0.69	0.64	0.61

- Maturity at age:

Age0	Age1	Age2	Age3	Age4	Age5
0.75	1	1	1	1	1

- 12 years for separable constraint
- Reference age for separable constraint = 1
- Constant selection pattern model
- S to be fixed on last age = 1.0
- F_{bar}: 1-3
- Catchability model = Linear
- Weight for surveys: Bottom trawl survey = 0.3; Acoustic surveys = 1.
- No shrinkage

6.1.2 Scripts

N/A

6.1.3 Results

The fishing mortality for age 1 (presented in figure 6.1, top-right) shows a constant decrease from 2000 up to 2007. Only in the last few years the F increased, remaining around F=0.4 and decreasing again in 2011 to the value of F=0.28. In 2011 the $F_{bar(1\text{-}3)}$ is equal to 0.61.

The mid-year biomass (figure 6.1, bottom-right) is fluctuating around the value of 300 thousand tons, reaching the maximum in 2005 (B = 436000 tons). In 2011 the estimated biomass is B = 333000 tons.

The recruitment (age 0 – figure 6.1, bottom-left) is quite stable, with fluctuations between 52578000 and 129050000 thousands individuals.

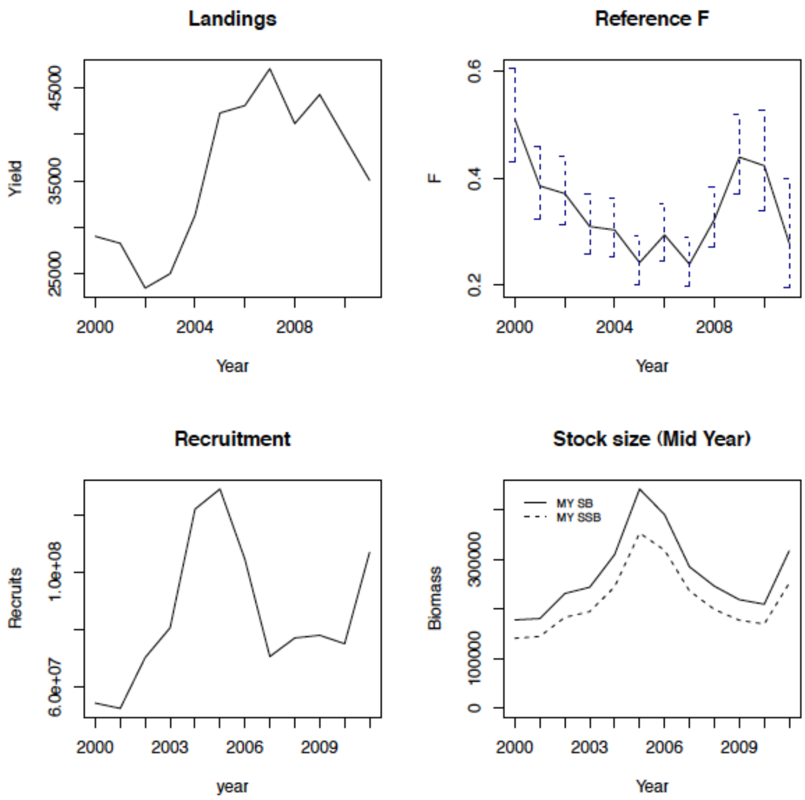


Figure 6.1: Total landings in tons (top-left); reference F (F for age 1) with the confidence interval for the separability period (top-right); recruitment (as thousands individuals)(bottom-left); mid-year stock biomass and SSB in tons (bottom-right).

Table 6.1 and 6.2 give respectively the stock numbers at age by year (in thousand) and the fishing mortality at age by year. In table 6.3 the mid-year stock biomass and the spawning stock biomass in tons are presented.

Table 6.1: Stock numbers at age by year (thousands)

	Age0	Age1	Age2	Age3	Age4	Age5
2000	54428000	3882900	1070100	148860	30020	33
2001	52578000	4991800	776120	119240	17328	41
2002	70296000	4856500	1130000	121220	19822	42
2003	80670000	6498300	1115100	183440	20990	49
2004	122050000	7483500	1586600	213880	37875	50
2005	129050000	11326000	1839100	309760	44992	26160
2006	104570000	12018000	2958400	423610	77580	268900
2007	70659000	9708900	2980900	592220	91498	94682
2008	77143000	6581200	2543300	692030	149560	48
2009	78068000	7151000	1586100	470850	137650	37
2010	75126000	7188900	1534000	214080	67104	38
2011	106980000	6924200	1567000	216240	31939	54

Table 6.2: Fishing mortality at age by year.

	Age0	Age1	Age2	Age3	Age4	Age5
2000	0.0291	0.5100	1.3844	1.4607	0.5100	0.5100
2001	0.0220	0.3856	1.0467	1.1043	0.3856	0.3856
2002	0.0212	0.3714	1.0081	1.0636	0.3714	0.3714
2003	0.0177	0.3099	0.8413	0.8876	0.3099	0.3099
2004	0.0173	0.3034	0.8236	0.8689	0.3034	0.3034
2005	0.0138	0.2425	0.6582	0.6945	0.2425	0.2425
2006	0.0168	0.2942	0.7985	0.8425	0.2942	0.2942
2007	0.0137	0.2396	0.6503	0.6862	0.2396	0.2396
2008	0.0184	0.3230	0.8767	0.9249	0.3230	0.3230
2009	0.0250	0.4394	1.1926	1.2583	0.4394	0.4394
2010	0.0241	0.4234	1.1493	1.2125	0.4234	0.4234
2011	0.0159	0.2790	0.7574	0.7991	0.2790	0.2790

Table 6.2: Mid-year Stock Biomass and Spawning Stock Biomass (tons).

	Mid-Year SB	Mid-Year SSB
2000	179452	142313
2001	189980	151968
2002	234577	185927
2003	246451	196408
2004	311572	246560
2005	436249	349399
2006	396179	323426
2007	281252	233686
2008	251750	203721
2009	220013	177946
2010	221918	179277
2011	333404	264565

The exploitation rate (F/(F+M)) is shown in figure 6.2.

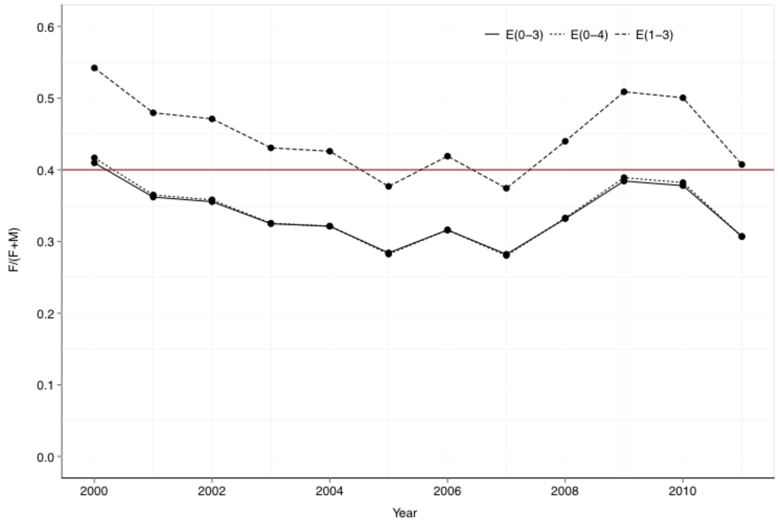


Figure 6.2: Exploitation rate (E = F/(F+M)) for age classes 0-3, 0-4 and 1-3 resulting from ICA analysis.

In figure 6.3 the harvest rate, calculate as the ratio between the catches and the estimates from the ICA model, shows a drop in the last year. The harvest rate calculated on the acoustic biomass estimates shows instead a decrease from 2005 up to now. Both the time series are constantly below 0.2.

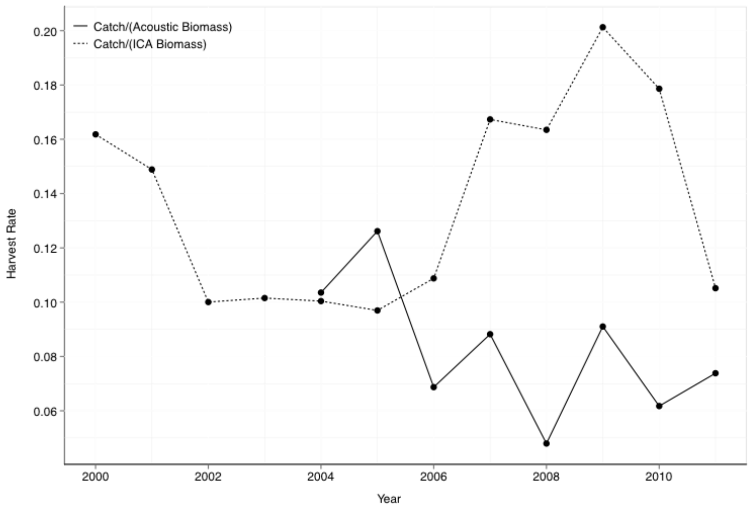


Figure 6.3: Harvest rate estimates (C/B) obtained from the mid-year ICA biomass (dashed line) and the acoustic biomass (full line).

The trend in biomass relatively to the proposed reference points is illustrated in figure 6.4.

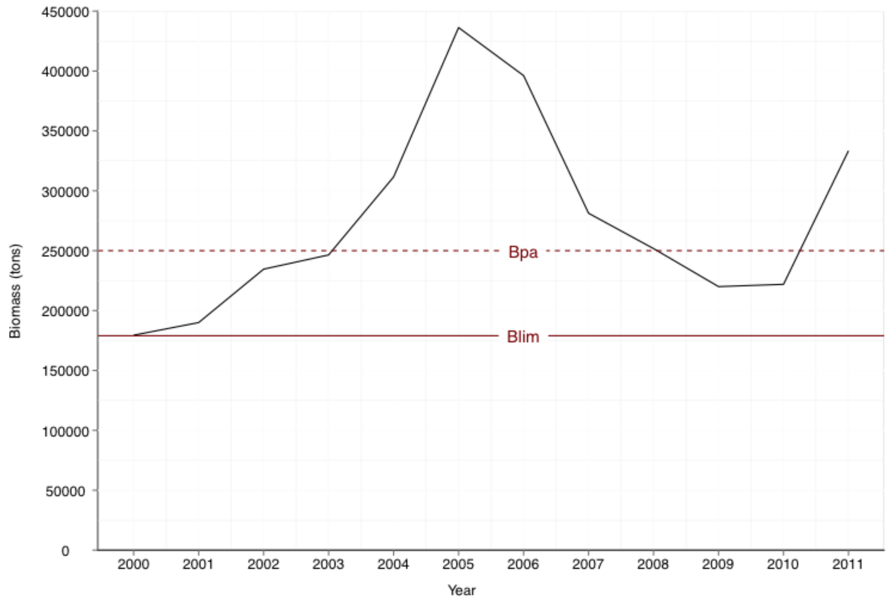


Figure 6.4: Mid-year stock biomass from the ICA analysis with the relative reference points (B_{lim} and B_{pa}).

6.2 Virtual Population Analysis

VPA was carried out applying the Laurec-Shepherd tuning with the acoustic survey index. This tuning procedure derives estimates of fishing mortality at age in the final year from an analysis of the logarithms of fleet catchabilities.
The software used for the analysis is the Lowestoft VPA software (Darby and Flatman, Version 3.1).

6.2.1 Model assumptions

- Tuning method: Laurec-Shepherd
- Tuning index: Acoustic Survey
- Ages 0 to 4+
- Oldest age F = 1.600*average of 2 younger ages
- M vector estimated using Gislason's equation (Gislason *et al.*, 2010):

Age0	Age1	Age2	Age3	Age4	Age5
2.36	1.10	0.81	0.69	0.64	0.61

- Maturity at age:

Age0	Age1	Age2	Age3	Age4	Age5
0.75	1	1	1	1	1

- No shrinkage

6.2.2 Results

VPA estimations of mid-year stock biomass, spawning stock biomass and trend in F by age are show in figures 6.5 and 6.6. The results are given in tables 6.4 and 6.5.
The biomass increases constantly up to a maximum in 2005 with about 450000 tons, then decreases until 2009 and then starts to increase again. The 2011 estimates is of 376500 tons.

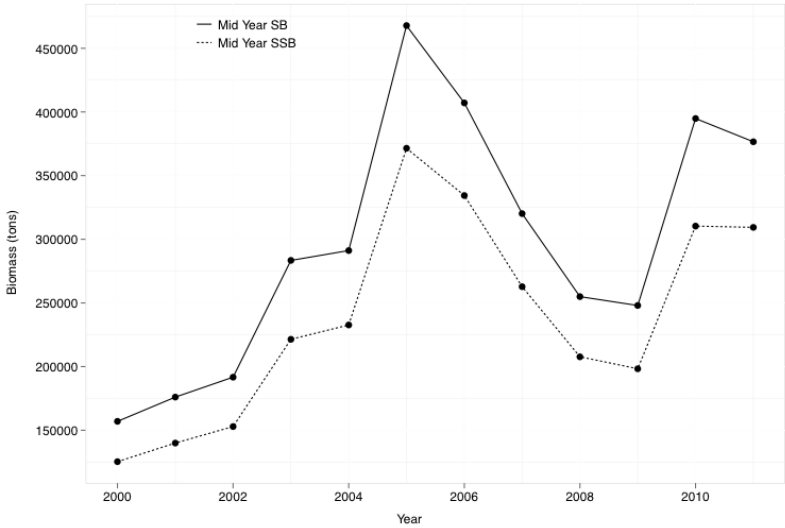


Figure 6.5: Mid-year biomass (full line) and mid-year SSB (dashed line) estimated by the means of the Laurec-Shepherd VPA.

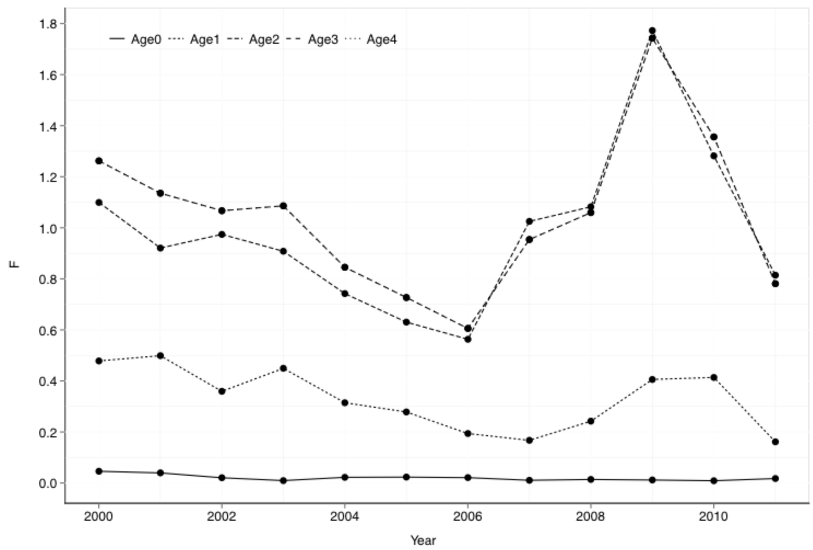


Figure 6.6: F by age estimated by the means of the Laurec-Shepherd VPA.

Table 6.4: Estimated numbers at age (in thousands).

	Age0	Age1	Age2	Age3	Age4
2000	46797100	3766500	849000	208000	16100
2001	50319700	4219900	777000	125800	6100
2002	56055300	4566800	853100	137700	12100
2003	99461900	5184700	1061400	143300	8400
2004	110057300	9302700	1101200	190400	17900
2005	143858300	10161600	2260700	233300	24700
2006	104769100	13271600	2560900	535500	245400
2007	85097600	9686100	3639400	648800	60500
2008	75709400	7949800	2727600	581000	79400
2009	91591500	7050100	2076900	411200	47200
2010	147736000	8546800	1563900	157000	27300
2011	104565900	13825200	1881200	193200	10300

Table 6.5: Estimated F at age.

	Age0	Age1	Age2	Age3	Age4
2000	0.0460	0.4784	1.0993	1.2622	1.2622
2001	0.0396	0.4987	0.9206	1.1354	1.1354
2002	0.0206	0.3592	0.9742	1.0668	1.0668
2003	0.0095	0.4493	0.9079	1.0858	1.0858
2004	0.0224	0.3146	0.7420	0.8453	0.8453
2005	0.0232	0.2783	0.6303	0.7268	0.7268
2006	0.0211	0.1938	0.5631	0.6055	0.6055
2007	0.0107	0.1673	1.0249	0.9537	0.9537
2008	0.0139	0.2423	1.0821	1.0595	1.0595
2009	0.0118	0.4058	1.7725	1.7427	1.7427
2010	0.0089	0.4136	1.2814	1.3560	1.3560
2011	0.0175	0.1614	0.8144	0.7807	0.7807

6.3 *Robustness analysis*

6.3.1 ICA

The diagnostic graph of the index SSQ against reference age F (age 1) from a separable VPA is plotted in figure 6.7. The curves should be U-shaped, with minima fairly close to each other on *x*-axis (Needle, 2000).

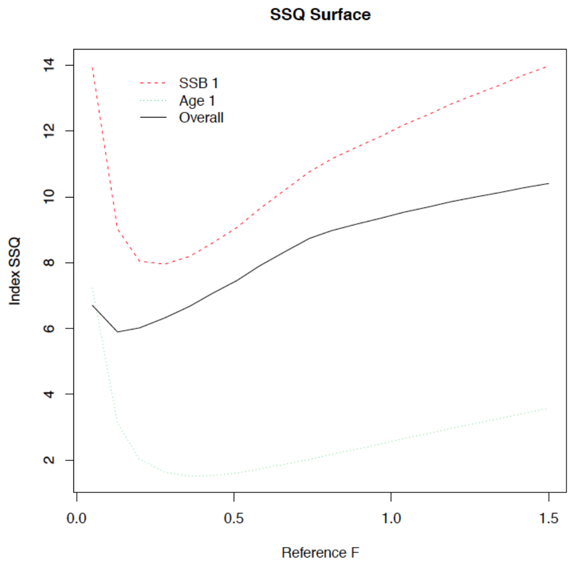


Figure 6.7: SSQ surface plot.

The marginal totals of residuals between the catch and the separable model are overall small, as well as reasonably trend-free in the separable period (2000-2011) (see figure 6.8).

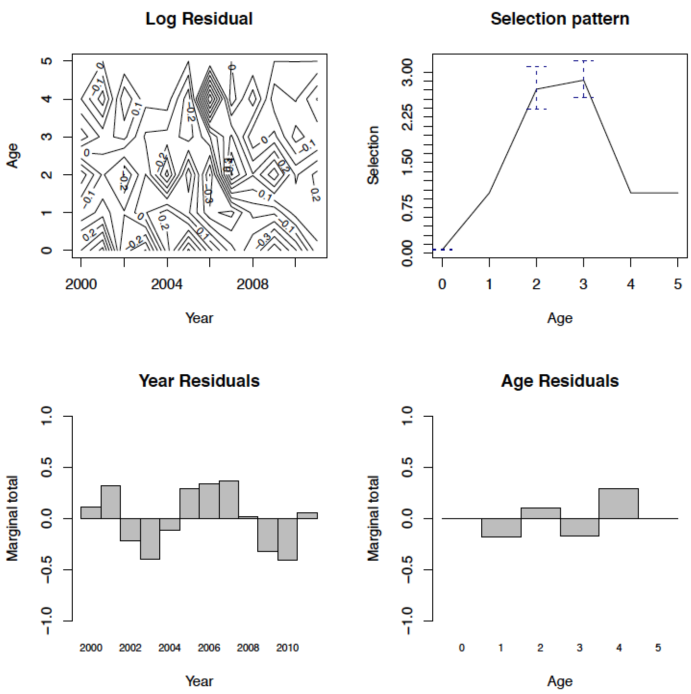


Figure 6.8: Diagnostics: log-residual contour plot (top-left); fitted selection pattern (top-right); year residuals for the catches (bottom-left); age residuals for the catches (bottom-right).

The diagnostics tables for the final run are given below (tables 6.6 and 6.7).

Table 6.6: Parameters estimates for the ICA run.

Separable model : F		Maximum Likelh. Estimate	CV %	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
1	2000	0.51	16	0.3656	0.7116	0.4303	0.6045	0.5174
2	2001	0.3856	17	0.2744	0.5419	0.3241	0.4587	0.3914
3	2002	0.3714	17	0.2651	0.5202	0.3127	0.4411	0.3769
4	2003	0.3099	18	0.2171	0.4425	0.2584	0.3717	0.3151
5	2004	0.3034	18	0.2124	0.4335	0.2529	0.364	0.3085
6	2005	0.2425	18	0.1675	0.351	0.2008	0.2929	0.2468
7	2006	0.2942	18	0.2062	0.4196	0.2454	0.3526	0.299
8	2007	0.2396	18	0.1662	0.3454	0.1988	0.2887	0.2438
9	2008	0.323	17	0.2293	0.4548	0.2712	0.3846	0.3279
10	2009	0.4394	16	0.3156	0.6116	0.3711	0.5201	0.4457
11	2010	0.4234	22	0.2743	0.6536	0.3392	0.5284	0.4339
12	2011	0.279	35	0.1381	0.5637	0.1949	0.3995	0.2976
Separable Model: Selection (S) by age								
13	0	0.057	15	0.0425	0.0765	0.049	0.0662	0.0576
	1	1	Fixed:	Reference Age				
14	2	2.7145	12	2.1097	3.4927	2.3869	3.087	2.737
15	3	2.8639	10	2.3352	3.5124	2.5807	3.1782	2.8795
	4	1	Fixed:	Last true Age				
Separable model: Populations in year 2011								
16	0	106982991	41	47664511	240123314	70822637	161605963	116482885
17	1	6924237	30	3841537	12480697	5126579	9352254	7244227
18	2	1566979	26	940359	2611157	1207579	2033345	1621073
19	3	216237	31	116826	400240	157946	296042	227174
20	4	31938	37	15388	66287	22004	46356	34233
Separable model: Populations at								
21	2000	30019	36	14607	61689	20787	43350	32116
22	2001	17327	30	9607	31250	12824	23410	18129
23	2002	19820	26	11731	33489	15167	25902	20543
24	2003	20988	26	12427	35448	16064	27422	21752
25	2004	37873	25	22960	62472	29338	48891	39128
26	2005	44990	25	27299	74146	34868	58052	46476
27	2006	77579	24	47960	125488	60699	99152	79949
28	2007	91496	25	56000	149493	71223	117541	94412
29	2008	149561	23	93615	238942	117762	189947	153896
30	2009	137645	24	85199	222375	107764	175812	141830
31	2010	67102	27	39155	114996	50977	88328	69685
Medits								
32	1Q	2.36E-04	20	1.93E-04	4.40E-04	2.36E-04	3.60E-04	2.98E-04
Age-structured index catchabilities (Acoustic Survey)								
Linear model fitted. Slopes at age :								
32	1Q	9.84E-04	31	7.26E-04	2.52E-03	9.84E-04	1.86E-03	1.42E-03
33	2Q	7.54E-03	30	5.60E-03	1.88E-02	7.54E-03	1.40E-02	1.08E-02
34	3Q	1.16E-02	31	8.61E-03	2.94E-02	1.16E-02	2.18E-02	1.67E-02
35	4Q	3.94E-03	33	2.87E-03	1.05E-02	3.94E-03	7.66E-03	5.81E-03
36	5Q	2.60E-04	34	1.87E-04	7.22E-04	2.60E-04	5.18E-04	3.90E-04

Table 6.7: Distribution statistics for the parameters.

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 2000 to 2011

Variance	0.1592
Skewness test stat.	1.4958
Kurtosis test statistic	0.2223
Partial chi-square	0.3813
Significance in fit	0
Degrees of freedom	29

PARAMETERS OF DISTRIBUTIONS OF THE SSB INDICES (Medits)

Linear catchability relationship

Last age is a plus-group

Variance	0.039
Skewness test stat.	0.6551
Kurtosis test statistic	-0.5216
Partial chi-square	0.1002
Significance in fit	0
Number of observations	11
Degrees of freedom	10
Weight in the analysis	0.3

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

Acoustic Survey

Linear catchability relationship

Age	0	1	2	3	4
Variance	0.1311	0.0938	0.062	0.0613	0.1618
Skewness test stat.	-0.9472	-0.3466	0.079	-0.1107	0.8822
Kurtosis test statisti	-0.28	-0.8077	0.0215	-0.6811	-0.4493
Partial chi-square	0.0745	0.0532	0.0398	0.0553	0.3332
Significance in fit	0	0	0	0	0.0007
Number of observations	7	7	7	7	7
Degrees of freedom	6	6	6	6	6
Weight in the analysis	0.2	0.2	0.2	0.2	0.2

The restrospective analysis (figure 6.9) doesn't show any particular trend for the biomass estimations, while it shows some degree of variation on the absolute levels of F in the last 2 years. Future investigations will aim to solve this problem.

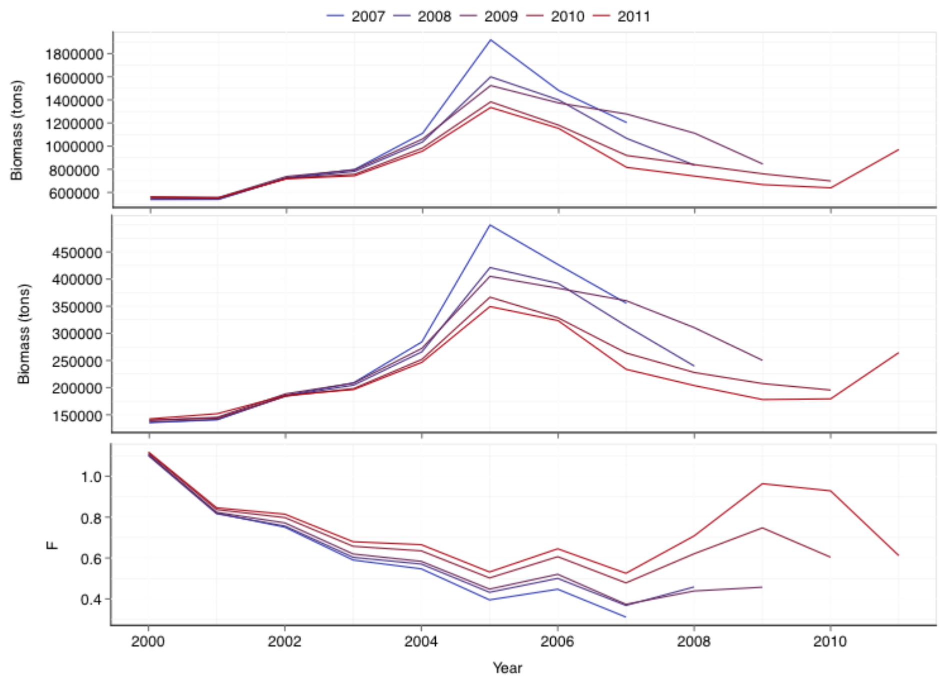


Figure 6.9: ICA Retrospective analysis for respectively total stock biomass at the beginning of the year (on top), mid year SSB (in the middle) and F (at the bottom).

The fitting of the model estimates with the acoustic surveys is shown in figure 6.10. The predicted numbers at age fit quite well the observed data, except for some disagreement in the first ages, which can be expected.

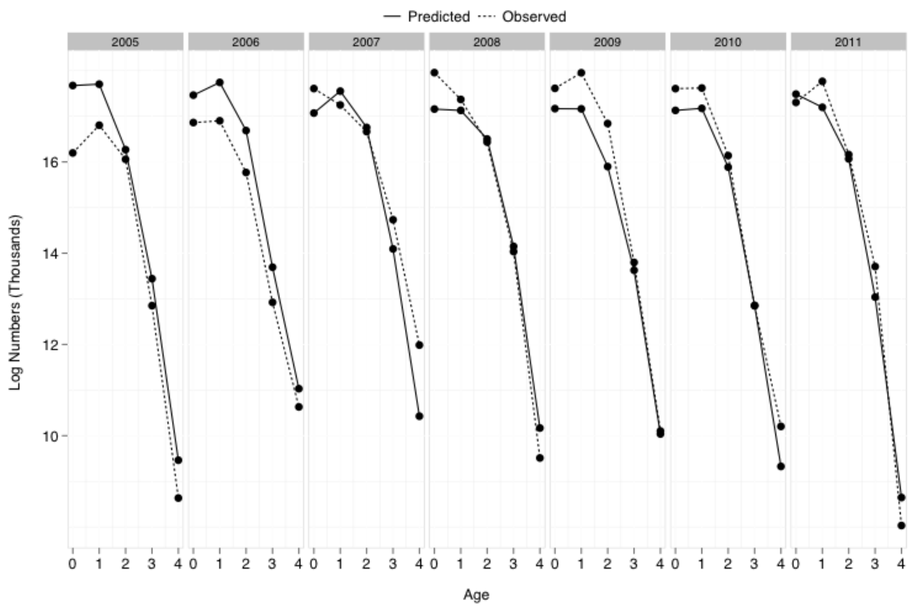


Figure 6.10: Predicted VS observed log numbers at age for the acoustic survey.

6.3.2 VPA

The summary statistic for the VPA run is shown in table 6.8.

Table 6.8: Summary statistic by age for the Laurec-Shepherd VPA.

SUMMARY STATISTIC FOR AGE 0

Fleet	Pred. Log q	se (log q)	Partial F	Raied F	Slope	se Slope	Intercept	se Intercept
1	-7.110	0.830	0.820	0.018	0.178	0.139	-7.106	0.293

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall	Variance ratio
0.017	0.830	0	0.830	0

SUMMARY STATISTIC FOR AGE 1

Fleet	Pred. Log q	se (log q)	Partial F	Raied F	Slope	se Slope	Intercept	se Intercept
1	-5.020	0.646	6.616	0.162	0.194	0.090	-5.018	0.228

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall	Variance ratio
0.161	0.646	0	0.646	0

SUMMARY STATISTIC FOR AGE 2

Fleet	Pred. Log q	se (log q)	Partial F	Raied F	Slope	se Slope	Intercept	se Intercept
1	-4.490	0.568	******	0.8144	0.153	0.086	-4.49	0.201

Fbar	Sigma(int.)	Sigma(ext.)	Sigma(overall	Variance ratio
0.814	0.568	0	0.568	0

The restrospective analysis (figure 6.11) shows high variability of the estimates for all the parameters.

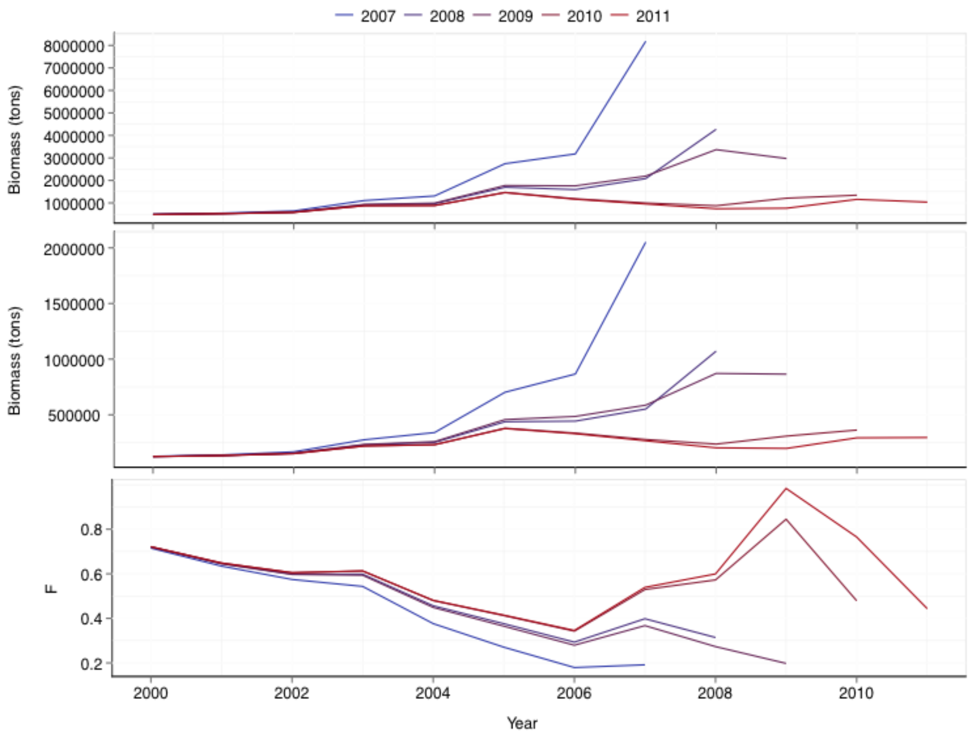


Figure 6.11: VPA Retrospective analysis for respectively total stock biomass at the beginning of the year (on top), mid year SSB (in the middle) and F (at the bottom).

The residuals for ln(q) shows a clear trend throughout the years (see figure 6.12) that was not possible to reduce.

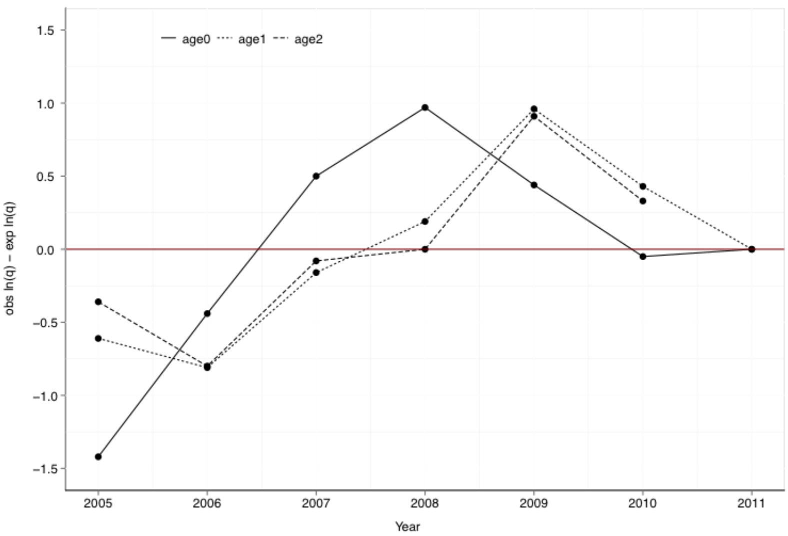


Figure 6.12: Observed log(q) – Expexted log(q) by age estimated by VPA analysis.

6.4 Assessment quality

The separable VPA performed well with the data available, reducing the retrospective pattern and improving the estimates of parameters, respect to the Laurec-Shepherd VPA.
The comparison between the resulting biomasses from the two models is shown in figure 6.13.

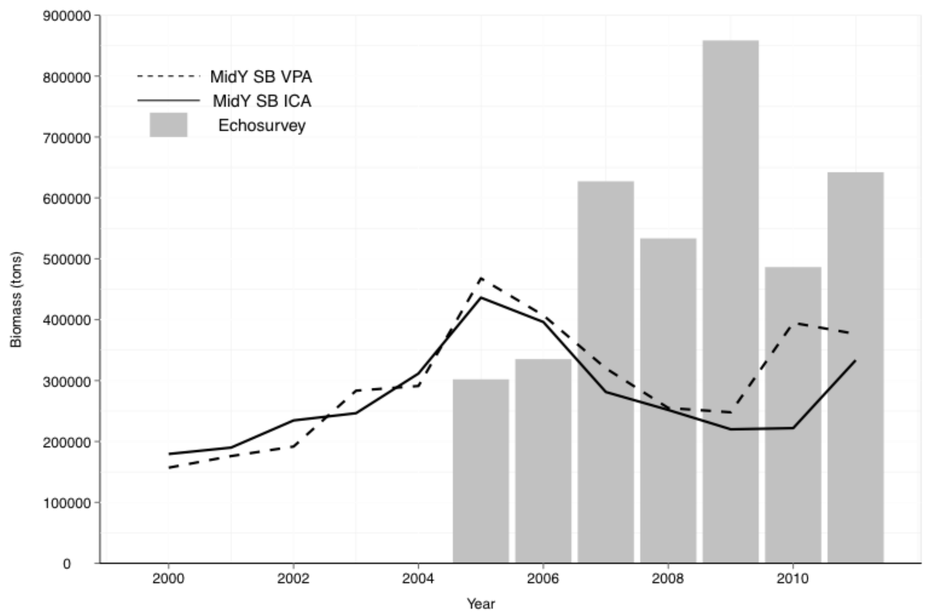


Figure 6.13: Mid year Stock Biomass from VPA (dashed line) and ICA (full line); split-year acoustic biomass estimates are shown as well in the form of background bars.

An ICA run was performed without the bottom trawl survey to test how much the inclusion of this index influences the model results. Despite a slight increase in the SSQ minimization, the CVs of the parameters estimations got worst. Besides, the resulting trend in biomass and F are almost identical, which was expected due to the really low weight gave to the index in the model.
ICA with absolute catchability model for the acoustic survey was attempted, but there was no way to stabilize the results: the SSQ and the CVs were really high, the residuals showed clear trends in ages and years with high values and the fitting with the acoustic survey got much worst.
In the present assessment there is improved coherence between the biomass estimated from the model and the survey data respect to last year assessment, although absolute values from the survey remain about double the estimates from the assessment models.

7 Stock predictions

N/A

7.1 Short term predictions

N/A

7.2 Medium term predictions

N/A

7.3 Long term predictions

N/A

8 Draft scientific advice

This year we will use the already approve reference point for F (Patterson) and another set of reference points for biomass.
The assessment shows an increase in the biomass trend starting in 2009 and the exploitation rate is around the reference point of E = 0.4 from Patterson ($E_{(1-3)}$ = 0.41). The 2011 total biomass (333404 tons) is above of both the proposed B_{lim} (179000 tons) and B_{pa} (250600 tons) reference points. The recruitment is increasing in the last year, and on the average it's quite stable, with little fluctuations compared to other small pelagic stocks.
The acoustic surveys show some fluctuations with no particular trend. The 2011 value is about 475000 tons.
It should be noted that Adriatic small pelagic fishery is multispecies and effort on anchovy cannot be separated from effort on sardine, so that most of the management decision have to be taken considering both species.
On the overall, the suggestion is not to increase the fishing mortality.

Table 8.1: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
[2000-2011]		[2000-2011]	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
X	Sustainable Fishing Mortality	X	Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Table 8.2: Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
[2000-2011]		[2000-2011]	
[179452 tons – 436249 tons]		[52578000 - 129050000 thousands]	
X	Stable	X	Stable
	Increasing		Increasing
	Decreasing		Decreasing

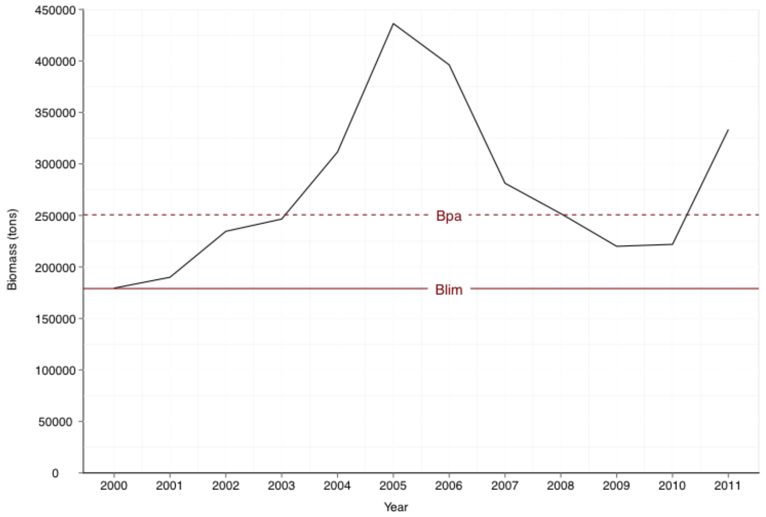


Figure 8.1: Mid year stock biomass and proposed reference points.

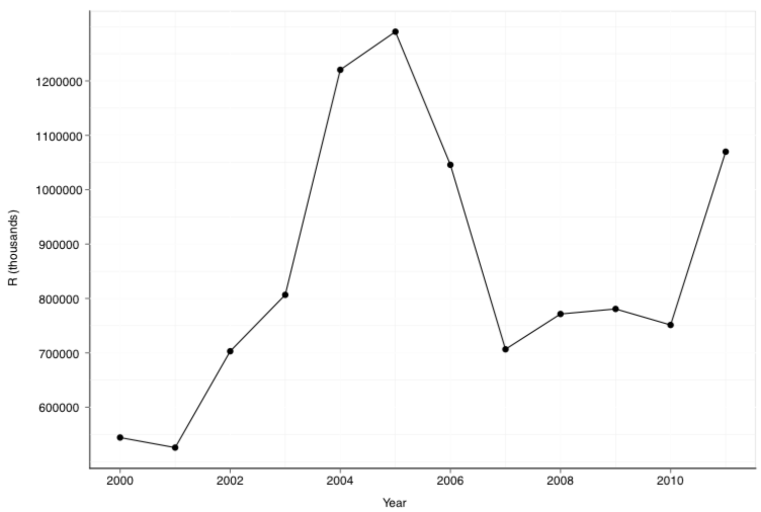


Figure 8.2: Recruitment estimates (in thousands).

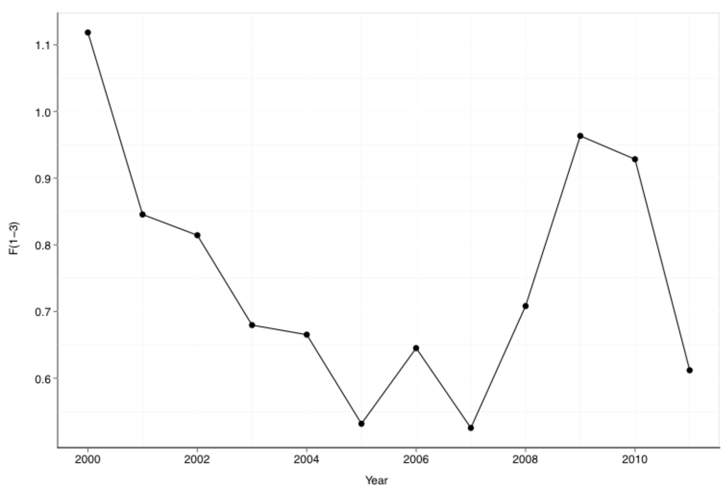


Figure 8.3: $F_{bar(1\text{-}3)}$ estimates.

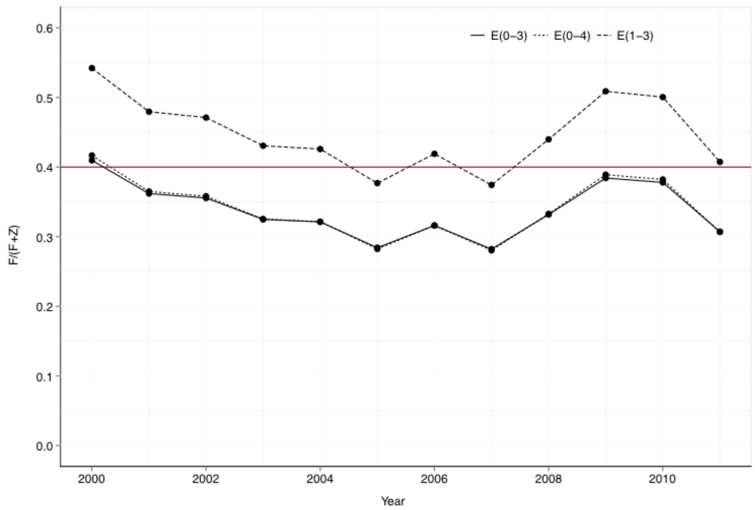


Figure 8.4: Exploitation rate (F/Z).

9 Bibliography

Bembo D. G., Carvalho G. R., Cingolani N., and Pitcher T. J. (1996). Electrophoretic analysis of stock structure in Northern Mediterranean anchovies, *Engraulis encrasicolus*. *ICES Journal of Marine Science*, 53:115-128.

Darby C. D. and Flatman S. (1994). Virtual Population Analysis: Version 3.1 (Windows/Dos) user guide. Info. *Tech. Ser. MAFF Direct. Fish. Res*., Lowestoft.

Gislason H., Daan N., Rice J. C., and Pope J. G. (2010*).* Size, growth, temperature and the natural mortality of marine fish*. Fish and Fisheries*, 11(2):149–158.

Magoulas A., Castilho R., Caetano S., Marcato S., and Patarnello T. (2006). Mitochondrial DNA reveals a mosaic pattern of phylogeographical structure in Atlantic and Mediterranean populations of anchovy (Engraulis encrasicolus). Molecular Phylogenetics and Evolution, 39:734-746.

MEDIAS, Report of 5th meeting for Mediterranean Acoustic Surveys (MEDIAS) in the framework of European Data Collection Framework (DCF) Sliema, Malta, 20-22 March 2012 Steering Committee Report.

MEDITS Working Group (April 2012). MEDITS-Handbook, Revision n. 6: 92 pp.

Patterson K. R. and Melvin G. D. (1996). Integrated catch at age analysis - version 1.2. *Technical Report 58*, The Scottish Office - Agriculture, Environment and Fisheries Department.

Patterson K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. *Reviews in Fish Biology and Fisheries*, 2:321–338.

Sbrana M., De Ranieri S., Ligas A., Reale B., Rossetti I. and Sartor P. (2010), Comparison of trawl survey and commercial data on small pelagics from the FAO geographic sub-area 9 (Western Mediterranean Sea). *Rapp. Comm. int. Mer Médit., 39*

Sinovcic G. (2000). Anchovy, *Engraulis encrasicolus* (Linnaeus, 1758): biology, population dynamics and fisheries case study. *Acta Adriatica*, 41(1):3–53.

Tudela S. (1999). Morphological variability in a Mediterranean, genetically homogeneous population of the European anchovy, *Engraulis encrasicolus. Fisheries Research*, 42: 229-243.

Stock Assessment Form version 0.9

Sprattus in GSA 29 (Black Sea)

1 Basic Identification Data

Scientific name:		Common name:		ISCAAP Group:	
Sprattus sprattus L.		Sprat			
1st Geographical sub-area:		2nd Geographical sub-area:		3rd Geographical sub-area:	
29					
Bulgaria	Romania	Ukraine	Russian Federation	Turkey	Georgia
Stock assessment method: (direct, indirect, combined, none)					
Indirect for GSA29					
Authors:					
Daskalov, G., Cardinale, M., Aysun Gümüş, Zengin, M., Panayotova, M., Duzgunes, E., Shlyakhov, V., Genç, Y., Radu, G., Yankova, M., Maximov, V., Mikhaylyuk, A., Raykov, V. and Rätz, H.-J. Casey, J., Abella, J. A., Andersen, J., Bailey, N., Bertignac, M., Cardinale, M., Curtis, H., Daskalov, G., Delaney, A., Döring, R., Garcia Rodriguez, M., Gascuel, D., Graham, N., Gustavsson, T., Jennings, S., Kenny, A., Kirkegaard, E., Kraak, S., Kuikka, S., Malvarosa, L., Martin, P., Motova, A., Murua, H., Nowakowski, P., Prellezo, R., Sala, A., Somarakis, S., Stransky, C., Theret, F., Ulrich, C., Vanhee, W. & Van Oostenbrugge, H.					
Affiliation:					
BS institutions, STECF					

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey x
- Egg production survey
- Trawl survey x

Indirect method (you can choose more than one):

- ICA -X
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify)

Combined method: you can choose both a direct and an indirect method and the name of the combined method (if it does exist)

2 Stock identification and biological information

The Black Sea sprat (*Sprattus sprattus L.*) is a key species in the Black Sea ecosystem. Sprat is a marine pelagic schooling species, sometimes entering in the estuaries (especially as juveniles) and the Azov Sea and tolerating salinities as low as 4‰. Sprat is one of the most important fish species, being fished and consumed traditionally in the Black Sea countries. It is most abundant small pelagic fish species in the region, together with anchovy and horse mackerel and accounts for most of the landings in the north-western part of the Black Sea. Whiting is also taken as a by-catch in the sprat fishery, although there is no targeted fishery beyond this (Raykov, 2006) except for Turkish waters. Sprat fishing takes place on the continental shelf on 15-110 m of depth (Shlyakhov, Shlyakhova, 2011). The harvesting of the Black Sea sprat is conducted during the day time when its aggregations become denser and are successfully fished with trawls. The main fishing gears are mid-water otter trawl, pelagic pair trawls and uncovered pound nets. The species is fast growing; age comprises 4-5 age groups. Sprat has lengths comprised between 50 and 120 mm, the highest frequency pertaining to the individuals of 70-100 mm lengths. The age corresponding to these lengths was 0+ - 4-4+, the ages 2-2+ - 3-3+ having a significant participation. By 1982, the age classes 4-4+ years had a share of 34% from the catch of this species, then the percentage continually decreased up to 1995 when this age was not signalled, meaning the increase of the pressure through fishing exerted on the populations. While the share of this age decreased, the prevalence of 0+ especially 1-1+ ages increased. During last years the age structure show the presence of the specimens of $1\text{-}1^+$ and 3; 3^+ years, the catch base being the individuals of $1\text{-}1^+$ and $2\text{-}2^+$ years.

2.1 Stock unit

It is assumed that sprat represent one stock shared among the Black Sea countries

2.2 Growth and maturity

The analysis of the gonad maturation (Table 2.1) shows that the majority of specimens were in the VI-II and II degree of maturation during fishing season. Peak of spawning activity take place in December-February.

Table 2.1: Maturity of sprat.

Year	Month	Sex	DEGREE OF MATURATION II	II-III	III	VI-II
2010	IV	F	85.14			14.86
		M	79.47			20.3
	V	F	81.32		11.39	7.29
		M	79.21		17.34	3.44
	VI	F	85.35		14.65	8.86
		M	74.29		25.71	
	VII	F	74.71		52.57	
		M	75.08		24.92	
	VIII	F				
		M				
	IX	F				
		M				
	X	F				
		M				
	XI	F	17.79		52.57	
		M	13.55	49	37.44	

Table 4.1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*					Units*	
Sex	Fem	Mal	Both	Unsexed		
Maximum size observed			11.8		Reproduction season	Nov-March
Size at first maturity			6.5		Reproduction areas	North western Black Sea
Recruitment size					Nursery areas	North western Black Sea coastal zone and marginal habitats

Table 4.13: Growth and length weight model parameters.

	L∞	k	t0	a	b
Bulgaria	12.57	0.82	**-0.662**	**0.0009**	**2.8811**
Romania	12.63	0.533	**-1.565**	**0.0089**	**2.8121**
Ukraine	12.42	0.286	**-1.504**	**0.008475**	**2.9691**
Turkey	14.23	0.14	**-3.27**	**0.05**	**3.065**

			Sex			
		Units	**female**	**male**	**both**	**unsexed**
Growth model	**L∞**					
	K					
	t_0					
	Data source	Daskalov et al., 2011				
Length weight relationship	**a**					
	b					

M (vector by length or age)	0.95				

sex ratio (% females/total)	F54:M46

3 Fisheries information

The sprat fishery is taking place in the Black Sea (GFCM Fishing Sub-area 37.4 (Division 37.4.2) and Geographical Sub-area (GSA) 29). The opportunities of marine fishing are limited by the specific characteristics of the Black Sea. The exploitation of the fish recourses is limited in the shelf area. The water below 100-150 m is anoxic and contains hydrogen sulphide. In Bulgarian, Romanian, Russian and Ukrainian waters the most intensive fisheries of Black Sea sprat is conducted in April till October with mid-water trawls on vessels 15- 40 m long and a small number vessels >40m. Beyond the 12-mile zone a special permission is needed for fishing. Harvesting of Black Sea sprat is conducted during the day, when the sprat aggregations become denser and are successfully fished with mid-water trawls.

The significance of the sprat fishery in Turkey in the last three years has increased and the landings reached 57 023 t in 2010. The main gears used for sprat fishery in Turkey (fishing area is constrained in front of the city of Samsun) are pelagic pair trawls working in spring at 20-40m depth and in autumn - in deeper water: 40-80m depths.

3.1 Description of the fleet

Table 4.1: Description of operational units in the stock.

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1	Bulgaria	29	24<40 12<18 18<24 6<12	OTM	Sprat, horse mackerel,bluefish,anchovy	Alosa immaculata,Atherina pontica,Raja clavata, Dasyatis pastinavca,M.merlangius, Squalus acanthias etc
Operational Unit 2	Bulgaria	29	-	FPN GNS	Sprat, anchovy, horse mackerel	Alosa immaculata,Atherina pontica,Raja clavata, Dasyatis pastinavca,M.merlangius,Squalus acanthias etc
Operational Unit 3	Romania	29	24<40	OTM	Sprat, anchovy, horse mackerel	Alosa immaculate,Atherina pontica,Raja clavata, Dasyatis pastinavca,M.merlangius, Squalus acanthias etc
Operational Unit 4	Romania	29	-	FPN,GNS	Sprat, anchovy,horse mackerel	Alosa immaculata,Atherina pontica,Raja clavata, Dasyatis pastinavca,M.merlangius, Squalus acanthias etc
Operational Unit 5	Ukraine	29	24<40 12<18 18<24 6<12		Sprat, anchovy,horse mackerel	Alosa immaculata,Atherina pontica,Raja clavata, Dasyatis pastinavca,M.merlangius, Squalus acanthias etc
Operational Unit 6	Turkey	29	24<40 12<18 18<24 6<12	OTM, Pair trawls, Purse seiners	Sprat, horse mackerel,bluefish,anchovy,bonito	Alosa immaculata,Atherina pontica,Raja clavata, Dasyatis pastinavca,M.merlangius, Squalus acanthias etc
Operational Unit 7	Russian Federation	29	24<40 12<18 18<24 6<12	OTM	Sprat, horse mackerel,bluefish,anchovy	Alosa immaculata,Atherina pontica,Raja clavata, Dasyatis pastinavca,M.merlangius, Squalus acanthias etc

Table 4.11: Catch, bycatch, discards and effort by operational unit.

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
1	32	3500 tons	sprat	M.merlangius,D.pastinaca,Raja clavata,Sq.acanthias, Alosa immaculata, etc	no	-	Kw*days/GT*days
2	59 stationary nets and 2000 GNS	600 t	sprat	M.merlangius,D.pastinaca,Raja clavata,Sq.acanthias, Alosa immaculata,Atherina pontica etc	no	-	Days deployed
3	2	10 t	sprat	M.merlangius,D.pastinaca,Raja clavata,Sq.acanthias, Alosa immaculata,Atherina pontica etc	1%	-	Kw*days, GT*days
4	22	29 t	sprat	M.merlangius,D.pastinaca,Raja clavata,Sq.acanthias, Alosa immaculata,Atherina pontica etc	-	-	Days, hours deployed
5	16	24652 t	sprat	M.merlangius,D.pastinaca,Raja clavata,Sq.acanthias, Alosa immaculata,Atherina pontica etc	-	-	Kw*days, GT*days
6	80	57023 t	sprat	M.merlangius,D.pastinaca,Raja clavata,Sq.acanthias, Alosa immaculata,Atherina pontica etc	-	-	Kw*days, GT*days
7	33	5800 t	sprat	M.merlangius,D.pastinaca,Raja clavata,Sq.acanthias, Alosa immaculata,Atherina pontica etc	-	-	Kw*days, GT*days
Total		91555 t					

Table 4.12: Catches as used in the assessment.

Classification	Catch (tn)
BG	4041
RO	39
UKR	24652
TU	57023
RU	5800
Total	91555

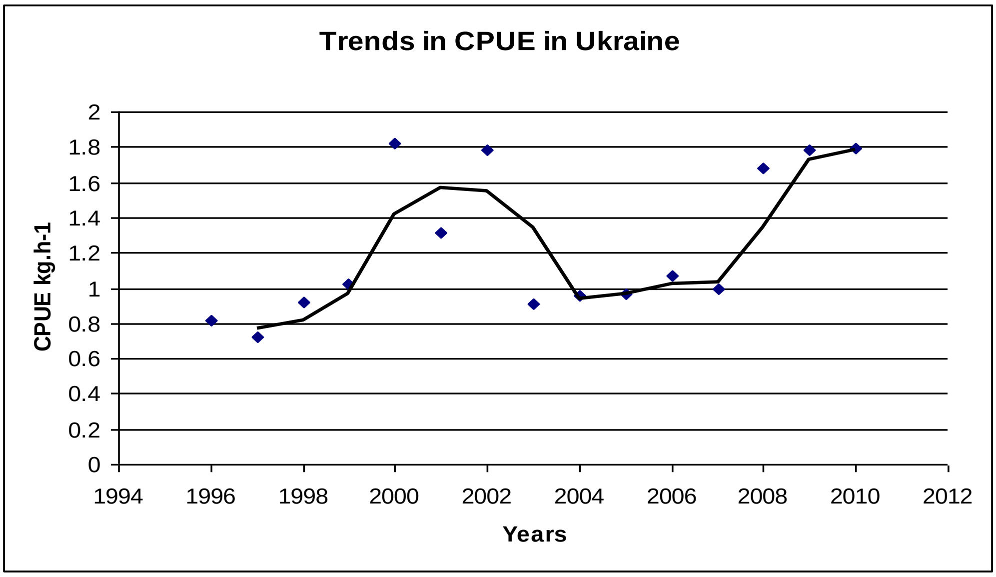
3.2 Historical trends

*Table 3.4: DCF nominal fishing effort (kw*days at sea) as submitted to JRC through the DCF 2011 Med and Black Sea data call by major gear type, 2008-2010.*

AREA	COUNTRY	GEAR	2008	2009	2010
SA 29	BUL	-1	18573751	15363673	25526826
SA 29	BUL	GNS	15666852	36979225	55479310
SA 29	BUL	OTM	6128829	9918196	11860801
SA 29	ROM	FPN	75773	118771	105152
SA 29	ROM	GNS	3247650	3991915	3640469
SA 29	ROM	OTM	212604	10520	662

Table 3.5: DCF fishing effort (number of vessels) as submitted to JRC through the DCF 2011 Med and Black Sea data call by major gear type, 2008-2010.

AREA	COUNTRY	GEAR	2008	2009	2010
SA 29	BUL	-1	270	245	299
SA 29	BUL	GNS	422	625	705
SA 29	BUL	OTM	24	32	26
SA 29	ROM	FPN	17	24	17
SA 29	ROM	GNS	116	114	127
SA 29	ROM	OTM	10	2	1



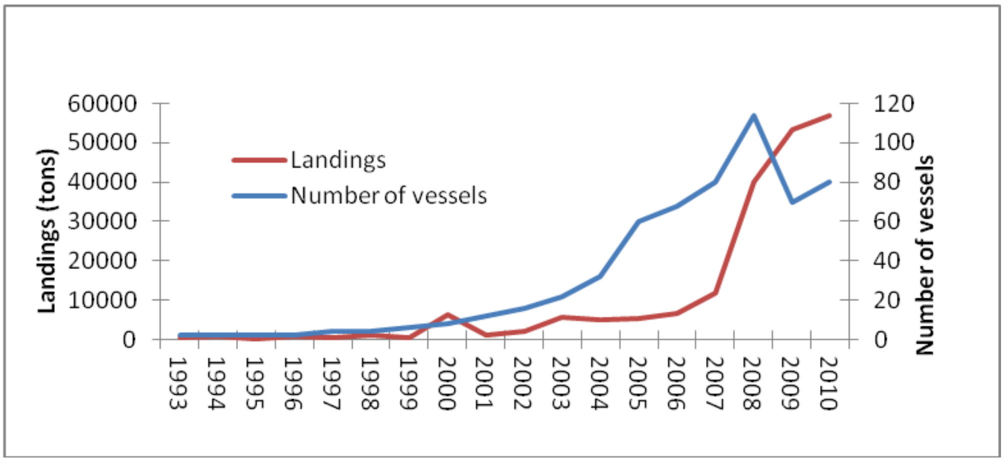


Figure 3.1: A. Historical trends in Ukraine (sprat) - B. Historical trends in Turkey (sprat).

3.3 Management regulations

A quota is allocated in EU waters of the Black Sea (Bulgaria and Romania). No fishery management agreement exists between other Black Sea countries. In the EU Black Sea waters a global (both Romania and Bulgaria) TAC 12 750 tons has been allocated in 2009 and 2010. This figure is a result of a reduction of the 2008 TAC of 15 000 t based on the precautionary principle. Ukraine and Russian Federation also apply TAC in their national waters (Table 4.1). Minimum landing size of sprat is applied across the region except in Turkish waters.
Table 4.2 Sprat TAC applied in Ukraine and Russian Federation in tons.

Table 3.1: Quota allocation in Russian and Ukraine national waters.

Year	Russian Federation	Ukraine
2005	42 000	60 000
2006		70 000
2007		40 000
2008	21 000	50 000
2009	21 000	50 000
2010	21 000	50 000
2011		60 000

Table 3.2: Minimum landing size of sprat in the Black sea region

	BG	GE	RO	RU	TR	UA
Sprattus sprattus	TL=7cm	SL=6cm	TL=7cm	SL= 6cm	NO	SL=6cm

3.4 Reference points

Table 3.3: List of reference points

Criterion	Current value	Units	Reference Point	Trend	Comments
B					
SSB	400000			stable	In the conditions of increased exploitation pressure, still stable biomass levels observed
F	0.59		=F≤0.64	increasing	The status quo proposed for the sprat stock advised up to 2013 is not likely to be sustained
Y	91555		100000 t	increasing	There are significant evidences that sprat landings increased last years. Possibly this could lead to over fishing (especially Turkey) in the following years.
CPUE					

4 Fisheries independent information

4.1 International (Bulgarian and Romanian) Pelagic Trawl Survey (PTS), June 2010.

Joint Pelagic Trawl Survey was carried out in June - July 2010 in the Romanian and Bulgarian Black Sea waters. Each of the regional teams has produced biological analyses of the results obtained in their area. The research vessel and fishing gear applied in the Romanian area in previous years, were applied in both areas.
All analyses are based on the biomass and density estimates by geographical strata and by countries. All the teams calculated their standard statistical estimates using the same software.
Biological data collection using mid-water trawl provided scientists with valuable information on population parameters such as size, age, sex composition, condition factor. Estimates of abundance, spatial distribution and migration are important source of information concerning population dynamics.
In the conditions of the Black Sea, sprat forms aggregations in the bottom layer below the thermocline. The main fishing gear in the sprat fishery is mid-water trawl (OTM) operating near the bottom. In the Black Sea and especially in its northwestern part assessments based on trawl survey had been conducted for 30 years by Ukraine, and from around 20 years by Romania and Bulgaria.
Starting from 2011 hydro acoustic survey will be used to assess sprat biomass.

4.1.1 Pilot international hydroacoustic survey in December, 2010

A pilot acoustic survey was conducted in front of the Bulgarian and Romanian Black Sea coasts, over the continental shelf between 42º50′ N and 43°50′ N and 28°00′ E and 29°30′ E in December 2010. Acoustic data were collected by using of EK 60 system (SIMRAD), operating at 38, 120 and 200 kHz simultaneously with hull-mounted split-beam transducers on the R/V "Akademik", Institute of Oceanology, Varna - Bulgarian Academy of Sciences. The main frequency for the assessment of fish biomass was 38 kHz. The 120 kHz and 200 kHz frequencies were used for discriminating fish, plankton, noise etc. GPS data were collected for pairing acoustic density readings with geographic location. A mid-water trawl, equipped with monitoring system based on SIMRAD ITI sensor was used for direct fishing and estimation of species composition and size frequency distribution. The ITI measures the trawl depth, vertical opening of the trawl mouth and temperature at the trawl depth.
The target fish species were sprat (*S. sprattus*) and whiting (*M. merlangus*). Furthermore, for zooplankton sampling, vertical Juday net (0.1 m^2, 200 µm mesh size) was used. Environmental measurements in each station were performed by CTD Seabird 911 sensor system for variables – temperature, salinity and dissolved oxygen, analyzed by Winkler method. Systematic parallel design was employed during the pilot hydroacoustic survey. For acoustic data acquisition, detailed echogram analysis and related calculations, the post-processing system LSSS was used. Data acquired by the 38 kHz transducer were used for extracting the sA values (nautical acoustic scattering coefficient (NASC), $m^2.nmi^{-2}$). The echointegration interval was 1 nm (1852 m).
For each species different target strength (TS) relationship was used. As no TS-length (L) relationship has been established for the two species, for this study the following target strength-length (TS) relationships were adopted:
Clupeoids: TS = 20 log L (cm) – 71.2
Gadoids: TS = 20 log L (cm) – 67.4

For biomass estimates, the surveyed area was divided into 4 polygons. For each polygon, the species composition in the identification hauls enabled sprat and whiting sA values to be estimated according to their proportion (in weight) in the catch. The biomass for each species was computed as the integral of surface density on the investigation area.

Table 4.1: Acoustic cruise information.

Date	December 2010		
Cruise		**R/V Akademik**	
Target species sprat and whiting			
Sampling strategy	**Transects north-south parallel to the coast**		
Sampling season	**Autumn-Winter**		
Investigated depth range (m) 40-110			
Echo-sounder SIMRAD EK60			
Fish sampler			
Cod –end mesh size as opening (mm) 6.5mm			
ESDU (i.e. 1 nautical mile)			
TS (Target Strength)/species **Sprat** 20 log L (cm) – 67.4 Whiting 20 log L (cm) – 71.2			
Software used in the post-processing	**LPSS**		
Samples (gear used)	**OTM**		
Biological data obtained	**Age, length, weight**		
Age slicing method - Shepard			
Maturity ogive used	1		

Table 4.12: Table Estimated number of sprat and whiting (millions) by age group and polygon, December 2010.

Polygon	Sprat (*10³)	Whiting (*10³)	Age groups (nbs, M)								
			S. sprattus				*M. merlangus*				
			1	2	3	4	1	2	3	4	5
1	16.75	24.628	7.92	7.67	1.16		8.132	9.99	3.02	3.25	0.23
2	1.7	2209.09	0.64	0.69	0.36	0.01	718.61	928.38	285.49	199.55	77.06
3	19.48		11.2	7.27	0.97	0.04					
4	63.57		37.22	25.75	0.61						
Total	101.5	2233.72	56.98	41.38	3.1	0.05	726.74	938.37	288.51	202.8	77.29

Table 4.3: Estimated biomass of sprat and whiting (tones) by age group and polygon, December 2010.

Polygon	Sprat (t)	Whiting (t)	Age groups (nbs, M)								
			S.sprattus				*M.merlangus*				
			1	2	3	4	1	2	3	4	5
1	67.58	0.48	28.85	32.7	6.03		0.08	0.15	0.09	0.15	0.02
2	7.41	33.86	2.4	2.94	1.97	0.1	5.71	10.22	5.75	7.55	4.63
3	81.93		44.33	31.54	5.75	0.3					
4	287.54		164.19	119.56	3.8						
Total	444.46	34.34	239.77	186.74	17.55	0.4	5.79	10.37	5.84	7.7	4.65

4.1.2 Spatial distribution of the resources

The densest sprat aggregations were detected in the shallowest stratum 10-35 m with average value of catch per unit area of 16 404 kg.km^{-2} and with average CPUA of 7428.6 kg.km^{-2} from all investigated stratums. During the survey the highest biomass indices were established in the stratum localized close to the shore -10 – 35 m in Bulgarian marine area. The biomass index in this stratum was 30 796.5 t. In the rest of the stratums the biomass was 2-3 times lower than in the shallowest stratum. The size composition ranged from 4.0 to 12.0 cm, the age ranged from 0+ to 4-4+, as oldest age groups and young-of-the-year was presented with low percentage. In Romanian waters sprat biomass was very high (at almost 10 times) in shallowest waters (stratum 10-35 m) in comparison with the stratums more distant from the coast - 35-50 m and 50-75 m.

Distribution pattern of catches per unit area during the spring survey in 2010 is presented on Fig 4.1.

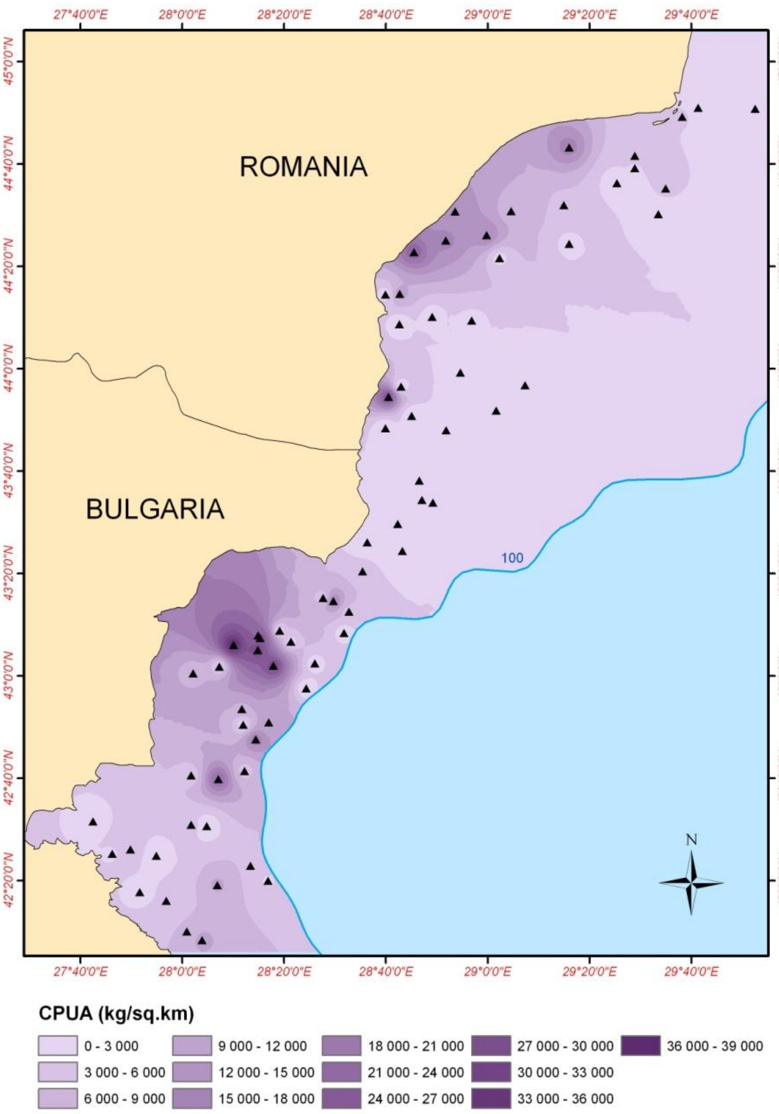


Figure 4.1: Catch per unit area kg.km^{-2} in Bulgarian and Romanian areas from the spring PTS.

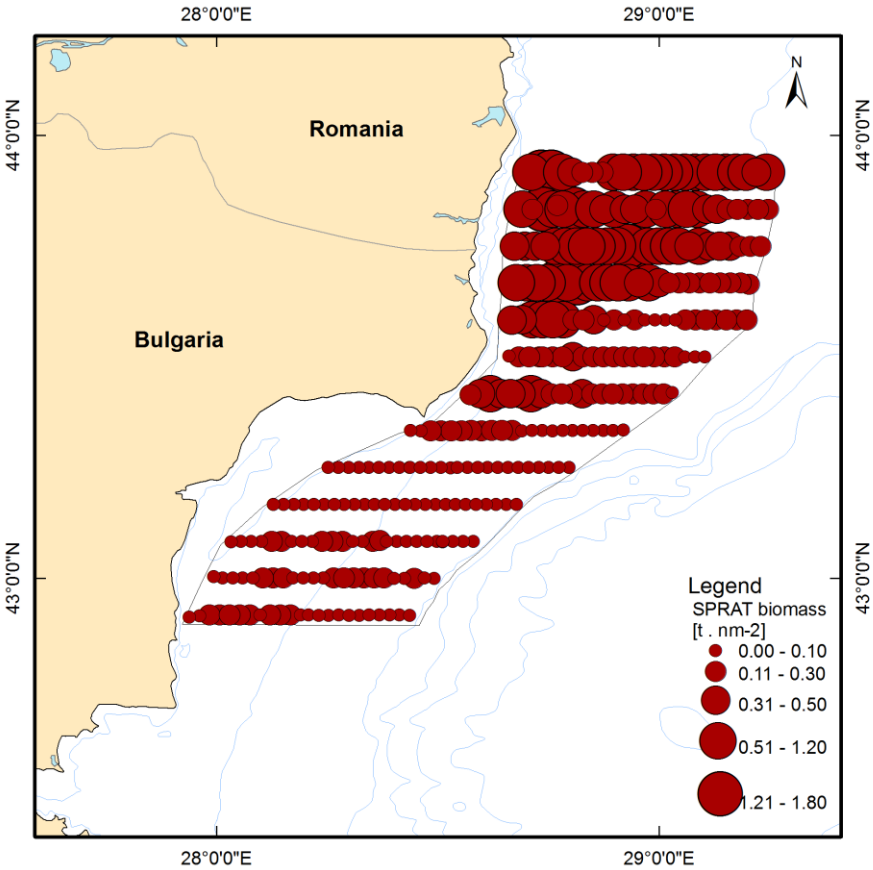
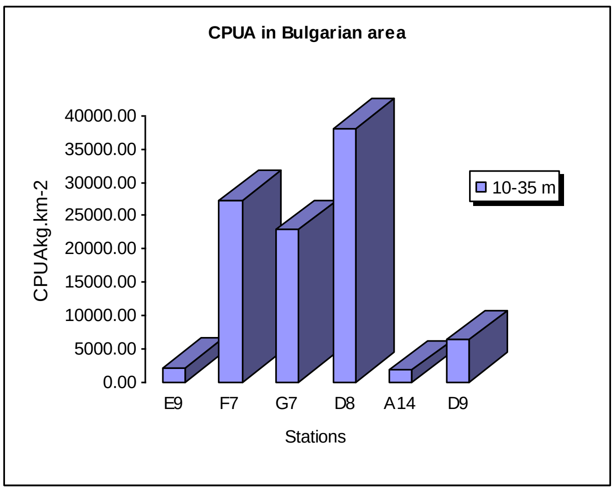


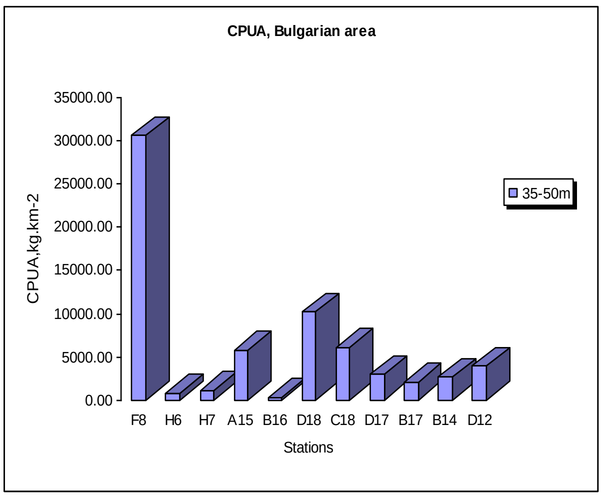
Figure 4.2: Distribution map of sprat biomass values (t.nm^{-2}), obtained during the acoustic survey of R/V "Akademik" in December 2010.

4.1.3 Historical trends

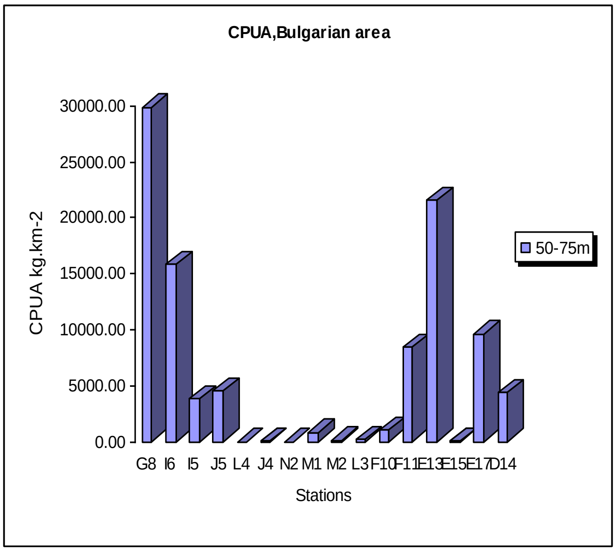
The calculated catches per unit area (CPUA) for the Bulgarian Black Sea area by strata are represented on Fig 4.3.

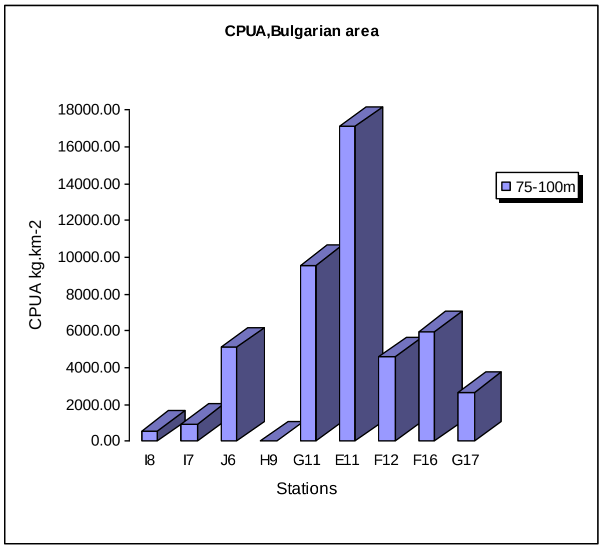


(a)



(b)





(c) **(d)**

*Figure 4.3: CPUA kg.km^{-2} by strata in the Bulgarian marine area; (**a**) CPUA kg*km^{-2} at strata 10-35m; (**b**) CPUA kg*km^{-2} at strata 35-50m; (**c**) CPUA kg*km^{-2} at strata 50-75m;(**d**) CPUA kg*km^{-2} at strata 75-100m.*

4.1.3.1 Trends in abundance at length or age

The CPUE indices of Romanian and Bulgarian pelagic trawl surveys are presented on Fig. 4.4. The trends show that Bulgarian biomass index increased in 2010 and the Romanian index stayed at the same level in 2008-2010.

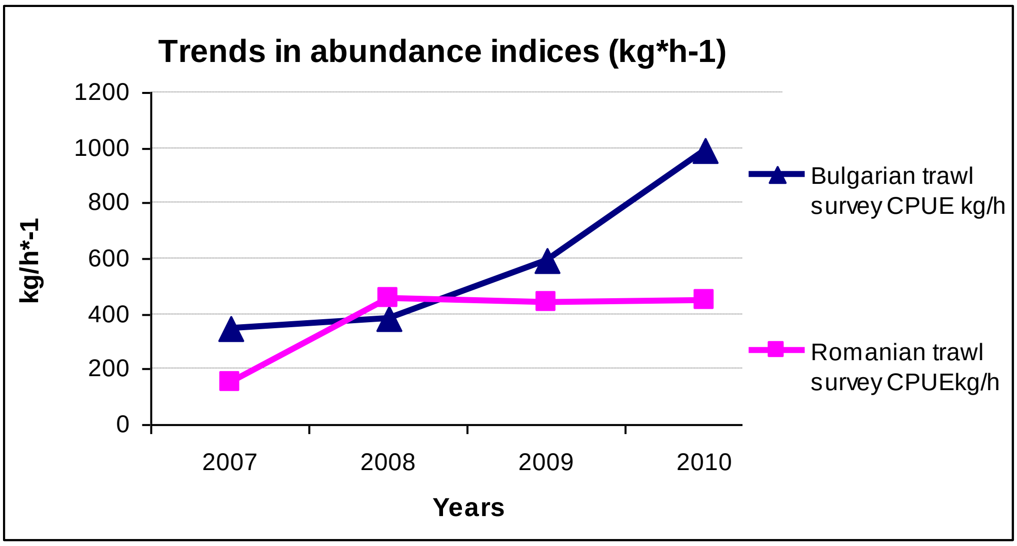
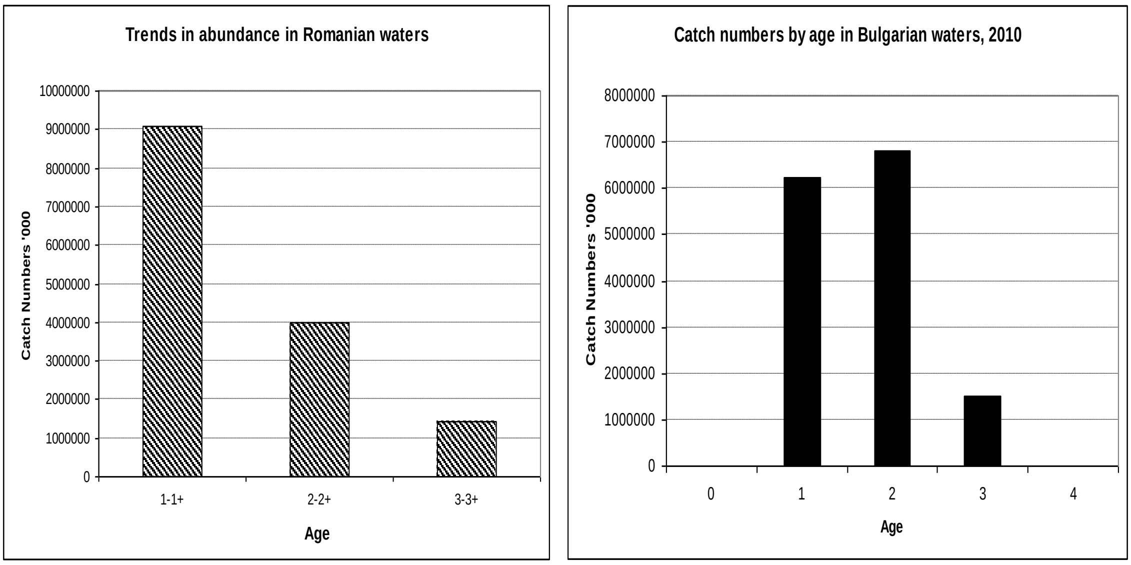


Figure 4.4: Trends in abundance (CPUE kg.h^{-1}) derived from Bulgarian and Romanian pelagic trawl surveys.

Catch numbers by age from surveys in Romania and Bulgaria show similar trends with prevailing age classes of 1-1+ and 2-2+.



(a) **(b)**

Figure 4.5: Trends in abundance by age from surveys in Romania ***(a)*** *and Bulgaria* ***(b)****.*

Commercial catch in Bulgaria was composed from 1-1+ and 2-2+ old specimen, mainly. Similar trends were observed in scientific surveys. Samples collected from Turkish pelagic trawls operating in shallow waters (40-60 m) also confirm the tendency that larger/older fish (Age 3 and 4) is distributed mostly in deeper waters.

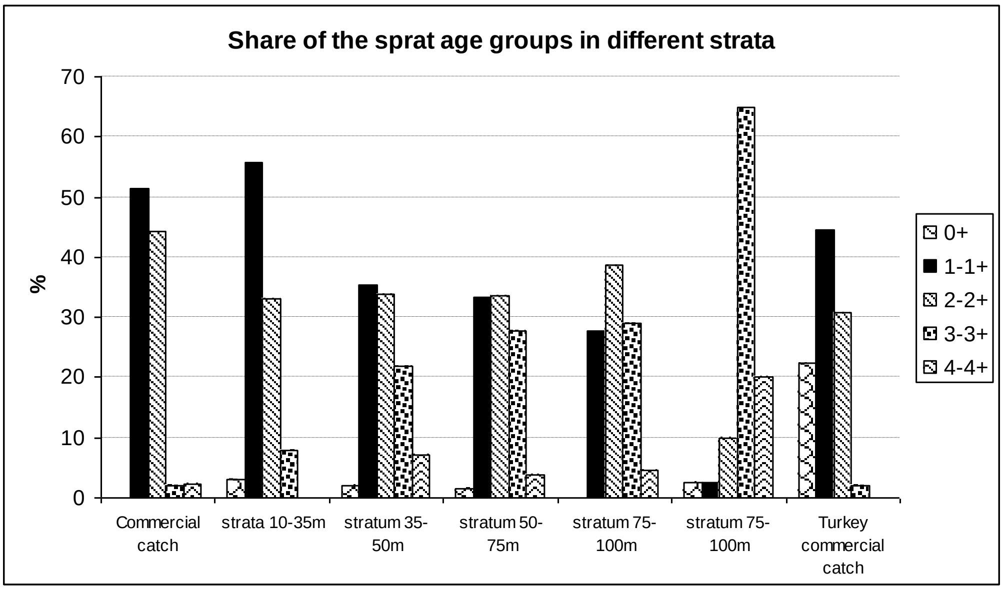


Figure 4.6: Age composition of commercial and survey catches of sprat showing lower selectivity of larger/older fish by the Bulgarian commercial fleet and in shallower waters and compared with the Turkish commercial catches.

5 Ecological information

5.1 Protected species potentially affected by the fisheries

No estimation exist.

5.2 Environmental indexes

No report

6 Stock Assessment

6.1 Integrated catch analysis

6.1.1 Model assumptions

We used Integrated Catch-at-age Analysis (ICA; Patterson and Melvin, 1996). ICA is a statistical catch-at-age method based on the Fournier and Deriso models (Deriso et al., 1985). It applies a statistical optimization procedure to calculate population numbers and fishing mortality coefficients-at-age from data of catch numbers-at-age and natural mortality. The dynamics of a cohort (generation) in the stock are expressed by two non-linear equations referred to as a survival equation (exponential decay) and a catch equation:

$$N_{a+1,y+1} = N_{a,y} * exp(-F_{a,y} - M),$$

$$C_{a,y} = N_{a,y} * [1 - exp(-F_{a,y} - M)] * F_{a,y} / (F_{a,y} + M),$$

where C, N, M, and F are catch, abundance, natural mortality, and fishing mortality, respectively, and a and y are subscript indices for age and year.

The algorithm initially estimates population numbers and fishing mortality fitting a separable model, when F is assumed to conform to a constant selection pattern (fishing mortality-at-age), but fishing mortality by year is allowed to vary. The F matrix is then modelled as a multiplication of the year-specific F and the specified selection pattern. This procedure substantially diminishes the number of parameters in the model.

In its second stage, the ICA algorithm minimizes the weighted Sum of Square Residuals (SSR) of observed and modelled catch and relative abundance indices (CPUE), assuming Gaussian distribution of the log residuals:

$$min [\sum_{a,y} pc_{a,y} (log\ C_{a,y} - log\ \hat{C}_{a,y})^2 + \sum_{a,y,f} pi_{a,f} (log\ I_{a,y,f} - log\ \hat{I}_{a,y,f})^2,$$

where C, Ĉ, I, and Î are observed and estimated catch and age-structured index, respectively, and a, y, and f are subscript indices for age, year, and fleet, respectively. Weights associated with catches and different indices (pc, pi) are ideally set equal to the inverse variances of catch and index data, and can be calculated based on the residuals between modelled and observed values. However, weights are usually set by the user on the basis of some information about the reliability of different indices and current experience with modelling the stock. Indices are defined as related to population numbers by the equations:

$$\hat{I}_{a,y} = N_{a,y} * exp(-F_{a,y} - M)$$

$$\hat{I}_{a,y} = q_a * N_{a,y} * exp(-F_{a,y} - M)$$

$$\hat{I}_{a,y} = q_a * (N_{a,y} * exp(-F_{a,y} - M))^{k_a}.$$

The two unknown parameters (qa, an age-specific catchability, and k, a constant) are estimated according to the assumed relationship between the population and the abundance index, which has to be specified as being one of the above – identity, linear, or power, respectively.

6.1.2 Scripts

Output Generated by ICA Version 1.4

SPRAT 2010

Catch in Number

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	492.	51.	255.	115.	21.	108.	278.	236.	1009.	406.	809.	415.	1202.	445.	528.
1	8047.	2673.	2673.	2072.	1712.	2496.	2741.	2278.	3838.	4877.	10352.	6829.	5654.	6878.	6024.
2	1363.	2114.	1453.	2182.	2792.	2773.	2600.	2831.	3086.	3340.	6646.	7655.	5454.	3580.	4652.
3	106.	528.	218.	442.	418.	579.	830.	1741.	1302.	1313.	1269.	3090.	3024.	2666.	1602.
4	55.	96.	14.	13.	13.	17.	43.	82.	121.	110.	109.	182.	674.	278.	372.
5	0.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

x 10 ^ 6

Catch in Number

AGE	2006	2007	2008	2009	2010
0	1158.	3180.	1299.	1558.	2934.
1	5976.	5351.	7774.	12266.	7940.
2	2705.	1876.	3248.	7833.	7120.
3	785.	802.	1327.	3278.	4378.
4	92.	113.	168.	369.	316.
5	0.	0.	0.	0.	1.

x 10 ^ 6

Predicted Catch in Number

AGE	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	627.	798.	732.	1080.	1044.	1127.	1015.	1841.	2934.
1	6940.	5578.	4745.	6530.	5074.	5156.	7300.	12297.	13870.
2	6191.	6715.	3534.	4379.	3171.	2787.	3834.	9540.	9124.
3	3122.	3011.	2049.	1542.	972.	883.	1106.	2526.	3117.
4	170.	536.	301.	312.	105.	88.	121.	269.	273.

x 10 ^ 6

Weights at age in the catches (Kg)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	.001500	.001700	.001700	.002300	.002500	.002500	.002300	.002400	.002800	.002300	.001700	.001800	.001700	.001900	.002100
1	.002100	.002100	.002500	.003400	.003800	.003800	.003300	.004000	.003200	.003500	.002500	.002700	.002800	.002900	.003500
2	.004400	.004500	.003600	.004000	.004600	.005200	.004900	.005100	.005000	.004500	.004000	.004100	.004000	.004400	.004700
3	.007100	.006800	.006000	.004700	.005400	.006000	.006300	.007600	.006500	.006000	.006300	.005800	.006100	.006000	.006200
4	.009400	.008600	.007700	.007700	.006900	.007400	.007200	.009400	.007300	.007800	.006900	.007700	.006800	.007300	.007700
5	.010800	.010800	.010800	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000

Weights at age in the catches (Kg)

AGE	2006	2007	2008	2009	2010
0	.002000	.001700	.002300	.002400	.002100
1	.003300	.003300	.003400	.003100	.002900
2	.004300	.004900	.004300	.004000	.004400
3	.006000	.007200	.005200	.004900	.006500
4	.007300	.008700	.007000	.006000	.008000
5	.010000	.010000	.010000	.010000	.010000

Weights at age in the stock (Kg)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	.001500	.001700	.001700	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000
1	.002100	.002100	.002500	.003500	.003300	.002800	.002700	.003400	.002500	.003200	.003500	.003600	.003500	.003400	.003600

2	.004400	.004500	.003600	.004100	.004300	.004300	.004700	.004600	.004700	.004400	.004400	.004500	.004400	.004400	.004600
3	.007100	.006800	.006000	.004800	.004800	.004700	.005700	.006400	.005900	.005600	.005200	.006100	.005900	.006000	.006100
4	.009400	.008600	.007700	.006200	.005500	.005300	.006900	.008200	.007300	.007200	.006700	.007400	.007400	.007200	.007400
5	.010800	.010800	.010800	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000

Weights at age in the stock (Kg)

AGE	2006	2007	2008	2009	2010
0	.001000	.001000	.001000	.001000	.001000
1	.003600	.003600	.003100	.003100	.002500
2	.004600	.004700	.004200	.004100	.003500
3	.005700	.006300	.005600	.004700	.004500
4	.007400	.007600	.007000	.005400	.007100
5	.010000	.010000	.010000	.010000	.016000

Natural Mortality (per year)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000
1	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
2	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
3	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
4	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
5	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000

Natural Mortality (per year)

AGE	2006	2007	2008	2009	2010
0	0.64000	0.64000	0.64000	0.64000	0.64000
1	0.95000	0.95000	0.95000	0.95000	0.95000
2	0.95000	0.95000	0.95000	0.95000	0.95000
3	0.95000	0.95000	0.95000	0.95000	0.95000
4	0.95000	0.95000	0.95000	0.95000	0.95000
5	0.95000	0.95000	0.95000	0.95000	0.95000

Proportion of fish spawning

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	2006	2007	2008	2009	2010
0	0.0000	0.0000	0.0000	0.0000	0.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000

AGE-STRUCTURED INDICES

Bul

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	9.78	19.59	41.06	53.32	52.36	101.06	96.51	87.64	69.14	73.95	80.74	58.86	73.12	65.32	77.50
2	57.49	48.77	38.16	28.37	58.52	30.60	68.95	60.47	66.09	64.79	54.65	38.78	38.98	37.62	70.25
3	16.27	7.36	9.45	6.21	5.28	4.54	6.28	3.43	21.45	18.67	19.65	13.08	7.58	11.60	50.73
4	0.25	0.23	0.59	0.61	0.54	0.30	0.61	0.20	1.16	3.34	4.85	1.31	2.35	1.98	5.04

x 10 ^ 3

Bul

AGE	2009	2010
1	125.36	107.72
2	109.76	117.60
3	37.33	90.32
4	5.98	10.33

x 10 ^ 3

Ukr

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	124.38	80.94	111.12	58.09	59.67	97.40	222.49	193.27	158.30	76.22	125.47	113.57	180.31	127.15	284.84
2	74.90	103.68	118.27	50.40	68.14	85.43	146.35	118.28	179.30	76.02	46.40	88.14	69.18	24.19	55.49
3	8.05	9.43	9.43	10.52	46.52	37.49	66.40	22.53	76.56	47.52	54.76	29.98	24.67	16.90	37.53
4	0.51	0.14	0.66	0.72	2.36	0.56	6.10	2.15	4.65	10.87	5.06	8.06	2.52	0.10	3.07

x 10 ^ 3

Ukr

AGE	2009	2010
1	335.38	352.09
2	143.30	67.33
3	37.47	4.84
4	0.66	0.24

x 10 ^ 3

Bul survey

AGE	2007	2008	2009	2010
1	19352.	44034.	55081.	88238.
2	30667.	40393.	55722.	84987.
3	25733.	12928.	40543.	53350.
4	999.	1081.	9585.	7495.

Rom survey

AGE	2007	2008	2009	2010
1	20.57	72.15	53.94	135.33
2	26.50	40.97	72.32	26.07

x 10 ^ 3

6.1.3 Results

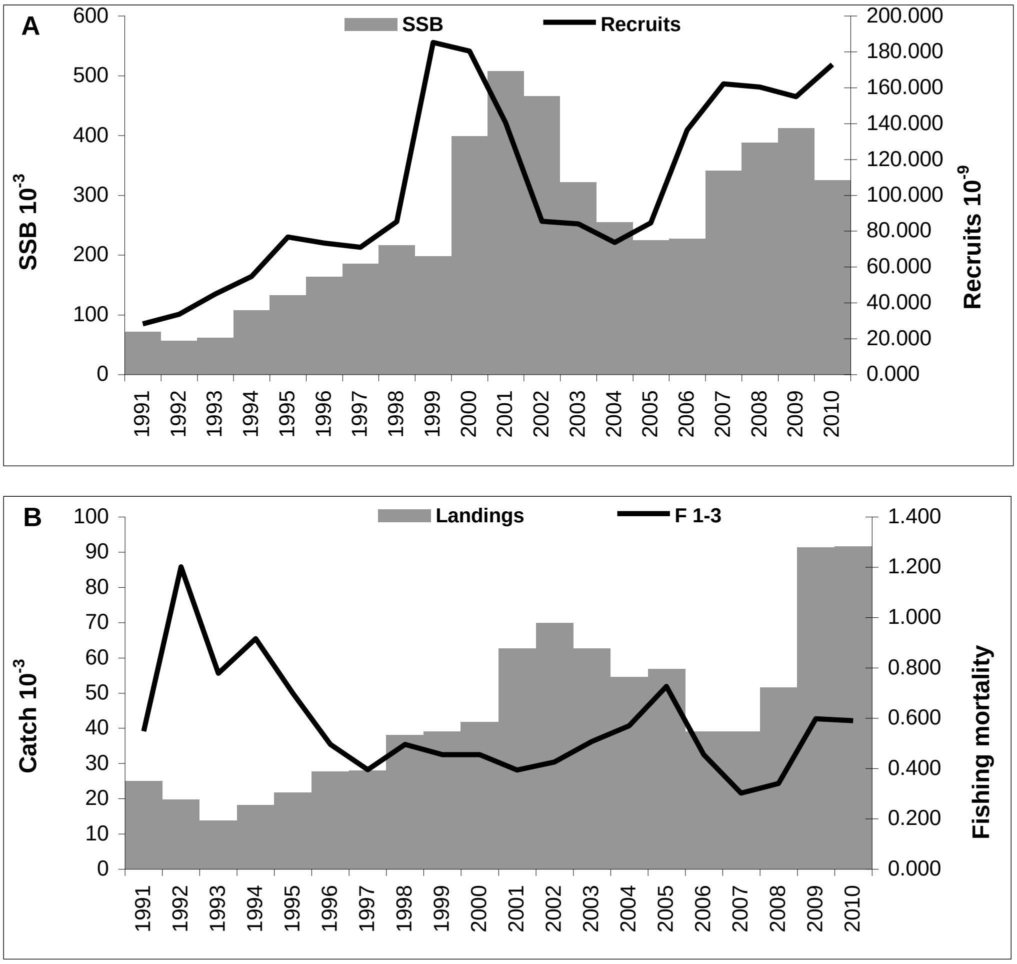


Figure 6.1: Time-series of sprat population estimates: A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 2–4, line).

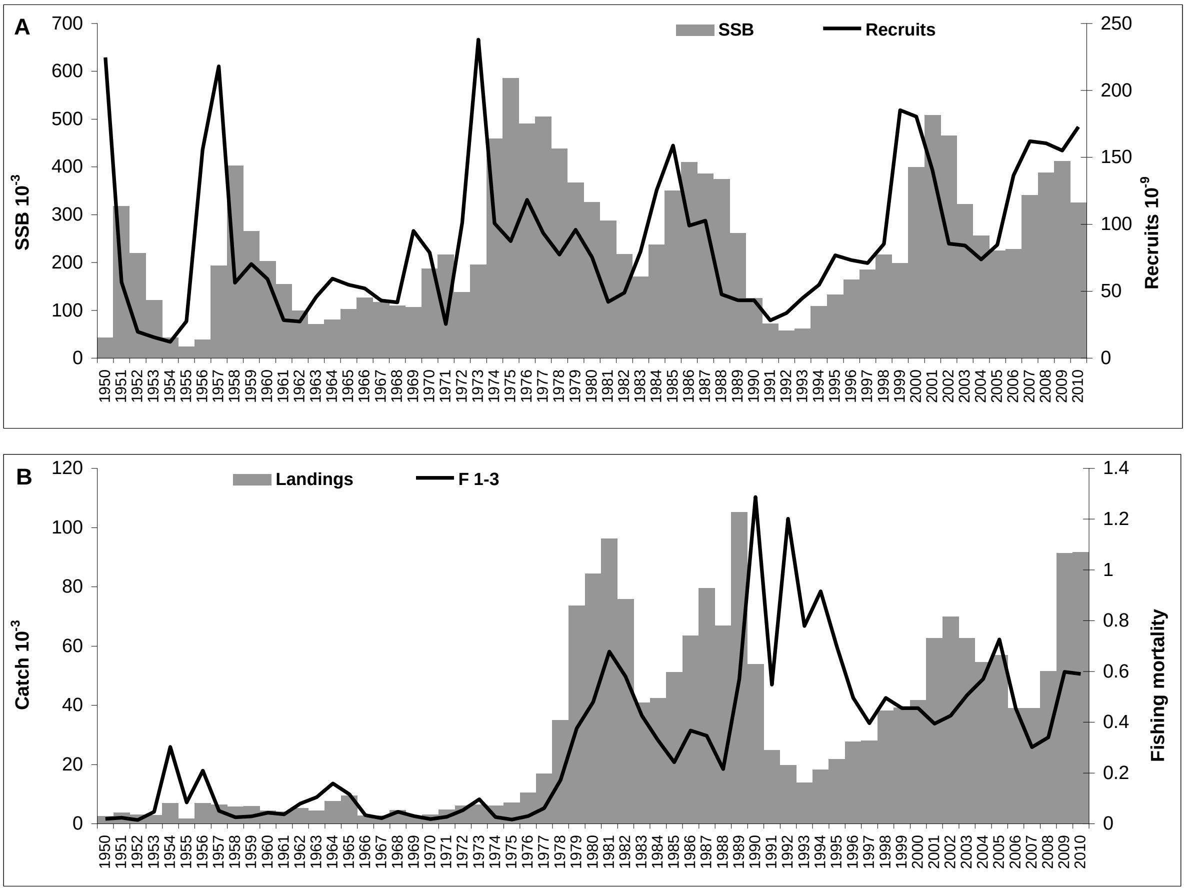


Figure 6.2: Time-series of sprat population estimates – present results combined with historical estimates from Daskalov 1998: A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 2–4, line).

6.2 Robustness analysis

N/A

6.3 Assessment quality

ICA combines the power and accuracy of a statistical model with the flexibility of setting different options of the parameters (e.g. a separable model accounting for age effects) and for this raison is suitable for a short living species (age 5 at maximum) such as the Black Sea sprat. ICA has previously been applied to Black Sea sprat by Daskalov (1998), Pilling et al. 2009, and Daskalov et al. 2010.

7 Stock predictions

The input parameters are listed in the Table 8.1 below. They do represent short term averages of the ICA inputs. The exploitation pattern used is the 2010 estimated vector rescaled to the average exploitation patterns estimated for the years 2008-2010. Due to the poor fit between the recruitment and survey index age 0 was set using the geometric mean from 2008-2010.

As the fishery for sprat in the Black Sea is not constrained by an international TAC, the intermediate year 2011 was defined as a status quo effort year with unchanged fishing mortality.

Table 7.1: Sprat in the Black Sea. Input to short term prediction.

2011

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	172832224	0.6400	0.0000	0.001	0.0151	0.0021
1	107930000	0.9500	1.0000	0.0025	0.2454	0.0029
2	24790000	0.9500	1.0000	0.0035	0.5240	0.0044
3	5440000	0.9500	1.0000	0.0045	1.0004	0.0065
4	910000	0.9500	1.0000	0.0071	0.5833	0.008
5	230000	0.9500	1.0000	0.016	0.5833	0.01

2012

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	172832224	0.6400	0.0000	0.001	0.0151	0.0021
1		0.9500	1.0000	0.0025	0.2454	0.0029
2		0.9500	1.0000	0.0035	0.5240	0.0044
3		0.9500	1.0000	0.0045	1.0004	0.0065
4		0.9500	1.0000	0.0071	0.5833	0.008
5		0.9500	1.0000	0.016	0.5833	0.01

2013

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	172832224	0.6400	0.0000	0.001	0.0151	0.0021
1		0.9500	1.0000	0.0025	0.2454	0.0029
2		0.9500	1.0000	0.0035	0.5240	0.0044
3		0.9500	1.0000	0.0045	1.0004	0.0065
4		0.9500	1.0000	0.0071	0.5833	0.008
5		0.9500	1.0000	0.016	0.5833	0.01

7.1 Short term predictions

7.1.1 Results

The following Table lists the single option status quo results of the prediction with stock parameters at age for 2011 to 2013.

Table 7.2: Sprat in the Black Sea. Single option (status quo) short term prediction.

2011	F-factor:	1	reference F1-3	0.5899		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0151	1909620	4010	172832224.2	172832	0	0
1	0.2454	15454784	44819	107930000	269825	107930000	269825
2	0.5240	6794313	29895	24790000	86765	24790000	86765
3	1.0004	2393430	15557	5440000	24480	5440000	24480
4	0.5833	271480	2172	910000	6461	910000	6461
5	0.5833	68616	686	230000	3680	230000	3680
		26892243	97139	312132224	564043	139300000	391211
2012	F-factor:	1	reference F1-3	0.5899		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0151	1909620	4010	172832224	172832	0	0
1	0.2454	12854538	37278	89770927	224427	89770927	224427
2	0.5240	8950295	39381	32656403	114297	32656403	114297
3	1.0004	2497802	16236	5677226	25548	5677226	25548
4	0.5833	230811	1846	773677	5493	773677	5493
5	0.5833	58590	586	196392	3142	196392	3142
		26501656	99337	301906849	545739	129074625	372907
2013	F-factor:	1	reference F1-3	0.5899		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0151	1909620	4010	172832224	172832	0	0
1	0.2454	12854538	37278	89770927	224427	89770927	224427
2	0.5240	7444420	32755	27162008	95067	27162008	95067
3	1.0004	3290409	21388	7478733	33654	7478733	33654
4	0.5833	240876	1927	807415	5733	807415	5733
5	0.5833	49813	498	166972	2672	166972	2672
		25789676	97856	298218279	534385	125386055	361553

The *status quo* fishing in 2011 would result in landings 97 139t, and SSB of 391 211 t, which are of similar size with landings 91 594 t and SSB - 324 938 t in 2010. The status quo model predicts increased catches of 99 337 t and 97 856 t, with the SSB decreasing to 372 907 t and 361 553 t in 2012 and 2013 respectively.

Recruitment estimates in 2008 and 2009 are rather imprecise due to the lack of survey data. Recruitment however seems to have entered in an increasing trend after 2006. In short-term forecast we used a geometric mean over 2008-2010 equal of 172 832 224 000.

Catches have been very high in the last two years due to quickly expending of Turkish fishery. Under the status quo F assumption, catches are expected to increase in 2012, and in 2013 keeping the level of 2011.

Given that the state of the stock depends greatly on a variable recruitment, the dynamic nature of developing Turkish sprat fishery and the lack of quota constraints on the sprat fisheries, the status quo assumption must be taken with caution when considered in management advice. However, the sprat stock looks healthy at present, and able to cope with present fishing pressure.

More management options through multiplications of the fishing mortality are given in the following Table

Table 7.3: Sprat in the Black Sea. Management option table (status quo in 2011) providing short term prediction.

2011					2012					2013		
F-factor	reference F	stock biomass	sp. stock biomass	catch in weight	F-factor	reference F	stock biomass	sp. stock biomass	catch in weight	stock biomass	sp. stock biomass	catch in weight
1.0000	0.5899	564043	391211	97139	0.0000	0.0000	546235	373403	0	600339	427507	0
					0.1000	0.0588	546235	373403	11823	592350	419518	14986
					0.2000	0.1177	546235	373403	23163	584741	411909	28415
					0.3000	0.1765	546235	373403	34042	577487	404655	40473
					0.4000	0.2353	546235	373403	44491	570565	397733	51319
					0.5500	0.3236	546235	373403	59402	560765	387933	65631
					0.6000	0.3530	546235	373403	64182	557645	384813	69941
					0.7000	0.4118	546235	373403	73470	551608	378776	77945
					0.8000	0.4706	546235	373403	82412	545831	372999	85214
					0.9000	0.5295	546235	373403	91029	540301	367469	91826
					1.0000	0.5883	546235	373403	99337	535001	362169	97856
					1.1000	0.6471	546235	373403	107353	529919	357087	103369
					ян.00	0.7059	546235	373403	115089	525042	352210	108422
					ян.00	0.7648	546235	373403	122562	520363	347531	113063
					ян.00	0.8236	546235	373403	129782	515865	343033	117336
					ян.00	0.8824	546235	373403	136765	511543	338711	121282

7.2 Medium term predictions

No medium term predictions are available

7.3 Long term predictions

Fmax could not be estimated due to shape to the YpR curve, which has a maximum well outside of the reasonable range. The skewed shape of the YpR curve results from the high natural mortality and the short life span of sprat in the Black Sea. Due to such effects, STECF EWG 11-16 on Black Sea does not consider $F_{0.1}$ as an appropriate management reference point, and proposes a limit reference point of exploitation rate E≤0.4 which implies Fmsy = 0.64. Given that the mean F=0.59 yields an exploitation rate of about E=0.38 (natural mortality M=0.95), the WG considers the stock of sprat in the Black Sea as sustainably exploited.

8 Draft scientific advice

State of the spawning stock size: According to the present assessment in recent years the SSB ranges at medium to high levels: in the range of 300 - 400 000 t. Under a constant recruitment scenario and status quo F, SSB is expected to stay at the approximate same level by 2013.

State of recruitment: After a positive trend in 1999-2001 the recruitment has decreased in 2002-2004 and increased again since 2006. Recruitment estimates in 2008 and 2009 are rather imprecise due to the lack of survey data. In short-term forecast we used a geometric mean over 2008-2010 average value of 172 832 224 000.

State of exploitation: Over the last few years the fishing mortality has piqued in 2005 and 2009 at a level of about F=0.59. This equals an exploitation rate of about E=0.38 (natural mortality M=0.95). Proposing a limit reference point of exploitation rate E≤0.4, the WG considers the stock of sprat in the Black Sea as sustainably exploited. Status quo fishing implies catches in the range of 90 000 to 100 000 t over 2011 - 2013.

Table 8.1: Unidimensional stock status (choose one).

Unidimnsional	**Not known or uncertain**. Not much information is available to make a judgment; **Underexploited, undeveloped or new fishery**. Believed to have a significant potential for expansion in total production; **Moderately exploited**, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production; **X Fully exploited.** The fishery is operating at or close to an optimal yield level, with no expected room for further expansion; **Overexploited.** The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse; **Depleted.** Catches are well below historical levels, irrespective of the amount of fishing effort exerted; **Recovering.** Catches are again increasing after having been depleted or a collapse from a previous; **None** of the above.

Table 8.2: Bidimensional stock status.

	Exploitation rate	Stock Abundance
Bidimensi onal	E≤0.4	400000t

Please note the two new definitions provided by the SAC:

Overfished (or overexploited) *- A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*

X Stock subjected to overfishing (or overexploitation) *- A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers)*

Stock Assessment Form

Horse mackerel in GSA 29 (Black Sea)

1 Basic Identification Data

Scientific name:	Common name:	GFCM Fishing Sub-area
Trachurus mediterraneus ponticus	**HORSE MACKEREL**	**37.4**
1st Geographical sub-area: 29	**2nd Geographical sub-area: 29**	**3rd Geographical sub-area: 29**
1st Country	2nd Country	3rd Country
Bulgaria	**Georgia**	**Romania**
4th Country	5th Country	6th Country
Russian Federation	**Turkey**	**Ukraine**
Stock assessment method: (direct, indirect, combined, none) **Separable VPA with varying terminal Fs (0.4, 0.8 and 1.2)**		

Practically, the horse mackerel (*Trachurus mediterraneus ponticus*), one of the intensively exploited pelagic species off the Black Sea Coast stock assessment is possible when the whole area of distribution of the species is included into examination.

Therefore, collection of samples in the waters of all Black Sea states (Bulgaria, Georgia, Romania, Russia, Turkey, Ukraine) and producing data for this pelagic species should take place.

However, due to the lack of funds and general agreement between the Black Sea states in Fishery (no legal document to regulate), no such joint scientific research expeditions take place.

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey
- Egg production survey
- Trawl survey

Indirect method (you can choose more than one):

- ICA
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify)

Combined method: you can choose both a direct and an indirect method and the name of the combined method (if it does exist).

2 Stock identification and biological information

Practically, the horse mackerel (*Trachurus mediterraneus ponticus*), one of the intensively exploited pelagic species off the Black Sea Coast stock assessment is possible when the whole area of distribution of the species is included into examination. Therefore, collection of samples in the waters of all Black Sea states (Bulgaria, Georgia, Romania, Russia, Turkey, Ukraine) and producing data for this pelagic species should take place. However, due to the lack of funds and general agreement between the Black Sea states in Fishery (no legal document to regulate), no such joint scientific research expeditions take place.

2.1 Stock unit

2.2 Growth and maturity

Table 4.11:Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*			LT		**Units***	cm
Sex	**Fem**	**Mal**	**Both**	**Unsexed**		
Maximum size observed				18.5	**Reproduction season**	Summer
Size at first maturity	11.7	11.6	11.7		**Reproduction areas**	Southern Black Sea
Recruitment size					**Nursery areas**	Southern Black Sea

Table 4.12: Growth and length weight model parameters

VBGF parameters calculated in the Black Sea

COUNTRY	YEAR_PERIOD	SPECIES	SEX	L_INF	K	t_0	A	b
Bulgaria	2007-2008	HMM	C	19.75	0.3020	-0.8305	0.0035	3.3046
Bulgaria	2007-2008	HMM	M	18.785	-0.3373	-0.8247	0.0034	3.3123
Bulgaria	2007-2008	HMM	F	19.661	-0.3075	-0.8359	0.0038	3.3029
Romania	2000	HMM	C	18.6	0.224	-1.43	0.0380	2.3552
Romania	2001	HMM	C	18.95	0.268	-0.63	0.0470	2.3501
Romania	2009	HMM	C	18.42	0.42	-0.41	0.0450	2.3469
Romania	2010	HMM	C	20.3	0.302	-0.467	0.0111	2.9065
Turkey	1991 – 1992	HMM	M	19.9	0.396	-1.02	0.0110	3.18
Turkey	1991 – 1992	HMM	F	20.6	0.356	-1.11	0.0080	2.993
Turkey *	2005	HMM	C	20.237	0.3181	-1.603	0.0081	2.9983
Turkey *	2006	HMM	C	22.394	0.241	-1.932	0.0064	3.0986
Turkey *	2007	HMM	C	22.232	0.2554	-1.828	0.0085	2.984
Turkey *	2008	HMM	C	22.244	0.2538	-1.8	0.0069	3.1018
Turkey *	2009	HMM	C	24.023	0.2082	-2.075	0.0062	3.1024
Turkey *	2010	HMM	C	25.002	0.187	-2.11	0.0052	3.1654
Ukraine	2008	HMM	C	18.5	0.343	-0.66	_	_

**data according "Purse seine fisheries monitoring project by Trabzon Central Fisheries Institute"*

3 Fisheries information

The horse mackerel (*Trachurus mediterraneus*) fishery operates mainly on the wintering grounds in the southern Black Sea using purse seine and mid-water trawls. The horse mackerel of age 1-3 years generally prevails in the commercial catches, but strong year classes (for example, the 1969-year class) may enter into exploitation at age of 0.5 year and may prevail up to age 5-6 years. Over the last 40 years, highest horse mackerel catches were reported in the years preceding *M. leidyi* outbreak (1988-1990). (Prodanov *et al*., 1997; FAO, 2007). The maximum catch of 141 thousand tons was recorded in 1985, from which ~100 thousand tons were caught by Turkey (Prodanov *et al*., 1997). In the next four years catches remained at the level of 97-105 thousand tons. In the period 1971-1989, the stock increased, although years of high abundance alternated with years of low abundance due to year class's fluctuations, typical of this fish. VPA estimates showed that the stock was highest in 1984-1988 (Prodanov *et al*., 1997). Scientists (Chashchin, 1998) believed that the intensive fishing in Turkish waters in 1985-1989 has led to overfishing of horse mackerel population and reduction of the stock and catches in the next years. A drastic decline in stock abundance occurred after 1990 when the stock diminished by 56%. In 1991 the horse mackerel stock dropped to a minimum of 75 thousand tons and the catch dropped to 4.7 thousand tons that is a twenty fold reduction compared to the average annual catch in 1985-1989. Marine fishery in the Black Sea traditionally has been carried out through active (bathypelagic trawls and surrounding nets) and passive fishing gears (gill netting, trap nets). The Bulgarian and Romanian catches are taken primarily by passive, while the former USSR entities by active gears (Prodanov et al., 1997). Horse mackerel stocks in the Black Sea are usually caught by Turkish fishermen by using active (bottom trawler, pelagic trawler and large bag-shaped nets) and passive (extension and longline) nets.

3.1 Description of the fleet

Table 4.1: Description of operational units in the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	BUL	29	FPO –Pound nets LOA=>6<12 LOA=>12<18	01 - Surrounding Nets		HMM
Operational Unit 2	BUL	29	OTM – Midwater otter trawl LOA=>12<18 LOA=>18<24 LOA=>24<40	03 - Trawls		HMM
Operational Unit 3						
Operational Unit 4						

<u>Legend:</u> LOA – Length overall of the fishing vessels.

Table 4.11: Catch, bycatch, discards and effort by operational unit.

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
Total							

Table 4.12: Catches as used in the assessment

Classification	Catch (tn)
2004	9633.90
2005	17602.40
2006	13625.33
2007	17886.08
2008	20842.85
2009	16489.06
2010	13405.50
Average 2004-2010	15918.11

3.2 Historical trends

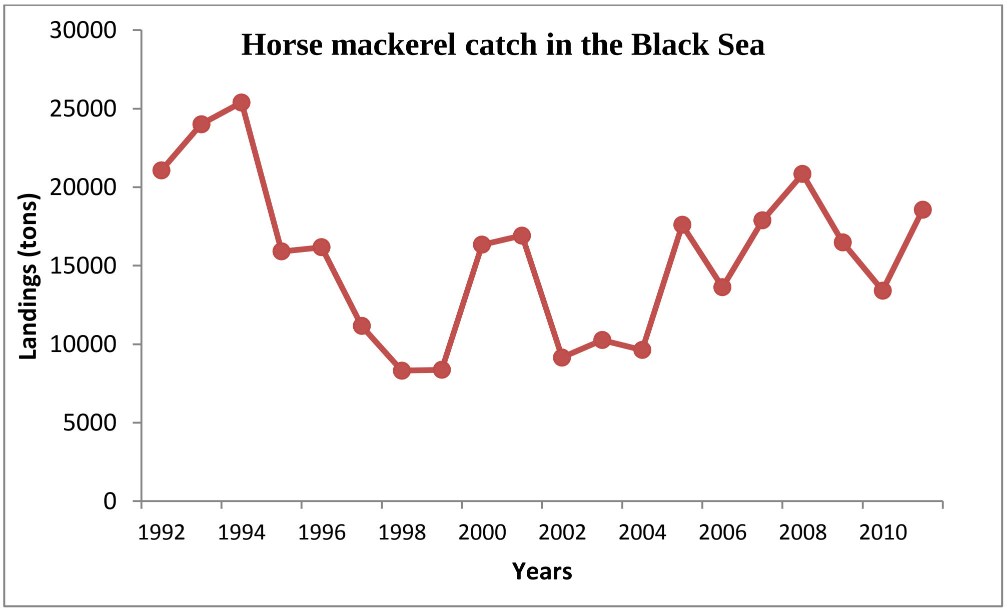


Figure 3.1: Trends in horse mackerel landings, years 1992-2010.

3.3 Management regulations

3.4 Reference points

Table 3.1: List of reference points

Criterion	Current value	Units	Referenc e Point	Tren d	Comments
B					
SSB					
F					
Y					
CPUE					

4 Fisheries independent information

N/A

4.2 Spatial distribution of the resources

N/A

4.3 Historical trends

N/A

5 Ecological information

5.1 Protected species potentially affected by the fisheries

N/A

5.2 Environmental indexes

N/A

6 Stock Assessment

6.1 Separable VPA with varying terminal Fs (0.4, 0.8 and 1.2)

6.1.1 Input data and model assumptions

STECF SG BLACK SEA 10-02 found out that data available in different national databases would allow performing a quantitative assessment of this stock. Data from the Turkish fisheries (~95% of the catch) will be very important but horse mackerel fisheries are quite important for rest of the Black Sea countries especially when the stock is high that assures a regular strong migration in the northern Black Sea. Fisheries and biological (age and individual size and growth) and survey data (acoustics, juveniles, and egg-production) from all countries need to be thoroughly compiled.

At the first stage data must be carefully screened and organized into age structured matrices. Age structured assessment methods such as VPA (XSA) and ICA than can be applied similar to sprat and turbot.
The lack of any tuning series to estimate terminal fishing mortalies in 2010, the EWG 11-16 decided to run 3 versions of separable VPAs with F=0.4, F=0.8 and F=1.2 as arbitrary inputs, respectively. This range has been chosen after a review of the results obtained from the Jones method (Ukrainian waters). The software used was FLR. The weight at age in the catch by age was calculated for all Black Sea countries. Total catch of species and aggregated catch at age in in number 10^{-3} of Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine was applied.

6.1.2 Scripts

N/A

6.1.3 Results

The analysis is a trend indicative only. The lack of a fishery independent scientific survey to monitor horse mackerel all over the Black Sea to indicate trends in total mortality and recruitment appears the major data deficiency in the assessment.

The following results are derived from the separable VPA based on a terminal F=0.4.

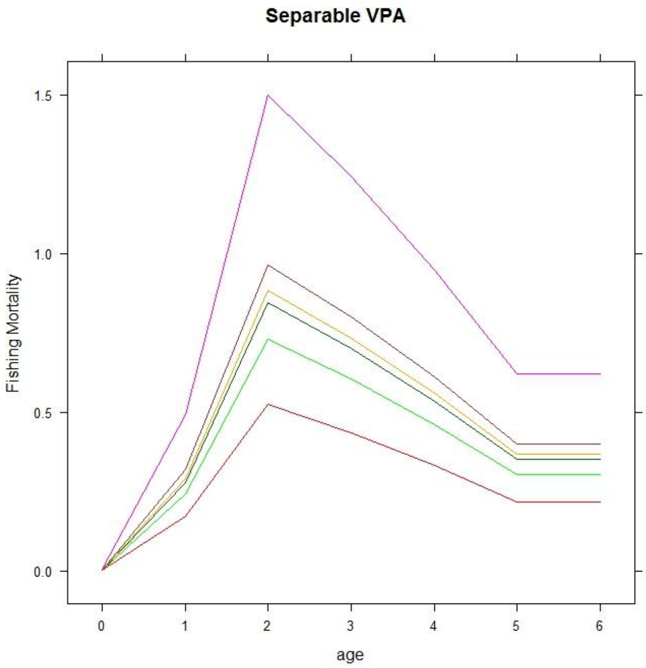


Figure 6.1: Selection patterns as derived from the separable VPA with F=0.4 as terminal F (after Daskalov et al., 2011).

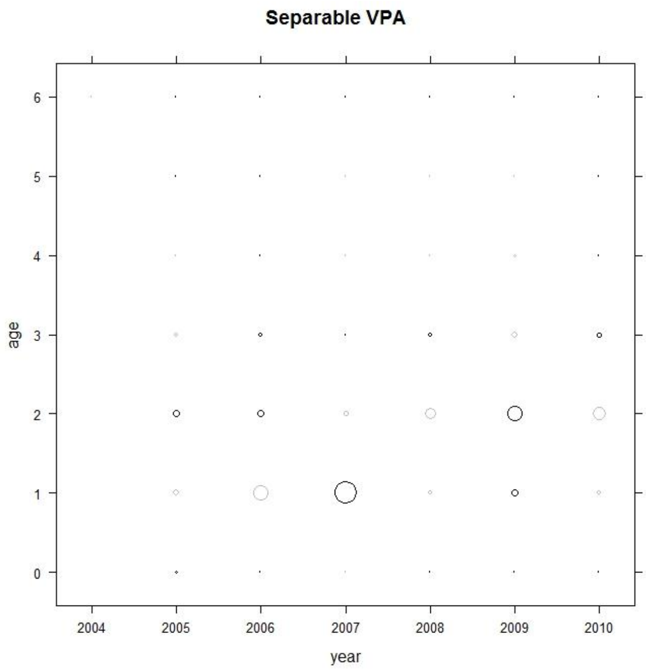


Figure 6.2. Residuals in estimated fishing mortalies (after Daskalov et al., 2011).

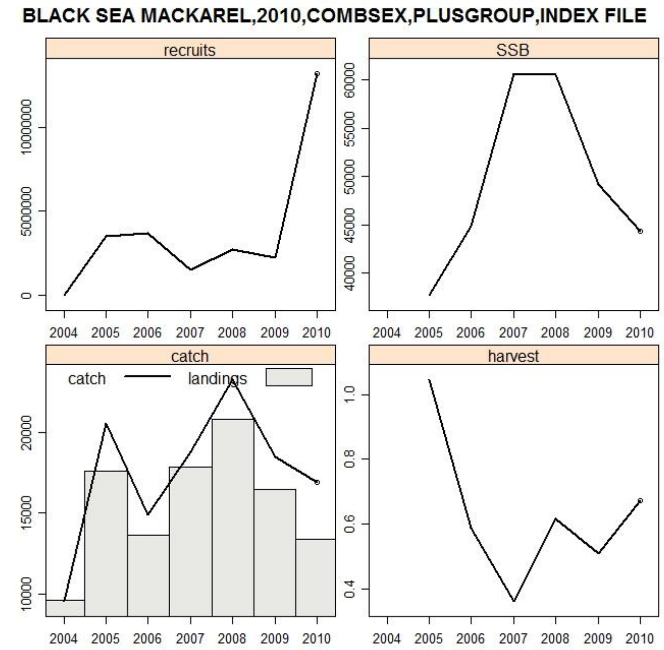


Figure 6.3 : Time-series of horse mackerel population estimates of total stock in the Black Sea (FLR for Quantitative Fisheries Stock Assessment Analysis with terminal F =0.4): A. recruitment (line) and stock spawning biomass (SSB); B. landings (grey) and catch (line) (after Daskalov et al., 2011).

The following results are derived from the separable VPA based on a terminal F=0.8.

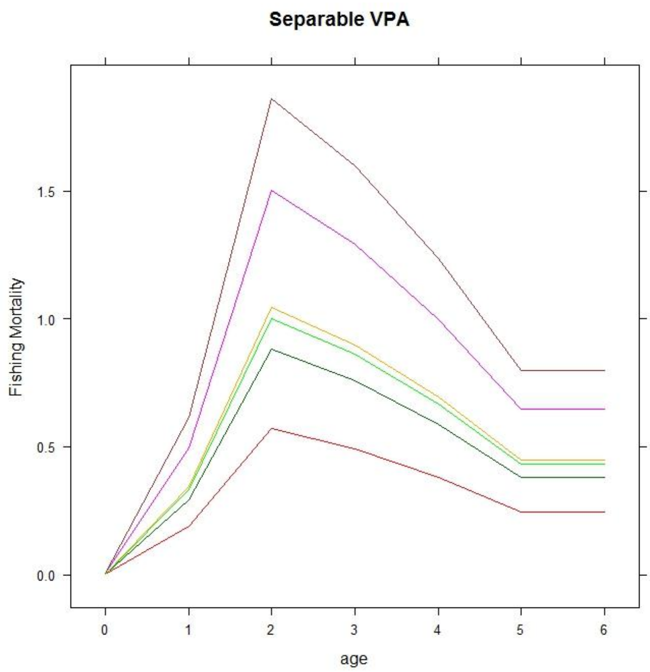


Figure 6.4: Selection patterns as derived from the separable VPA with F=0.8 as terminal F (after Daskalov et al., 2011).

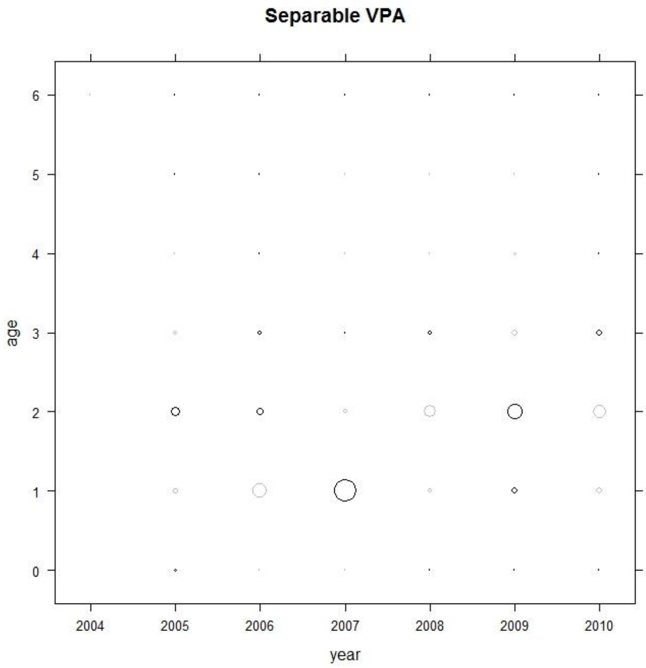


Figure 6.5: Residuals in estimated fishing mortalies(after Daskalov et al., 2011).

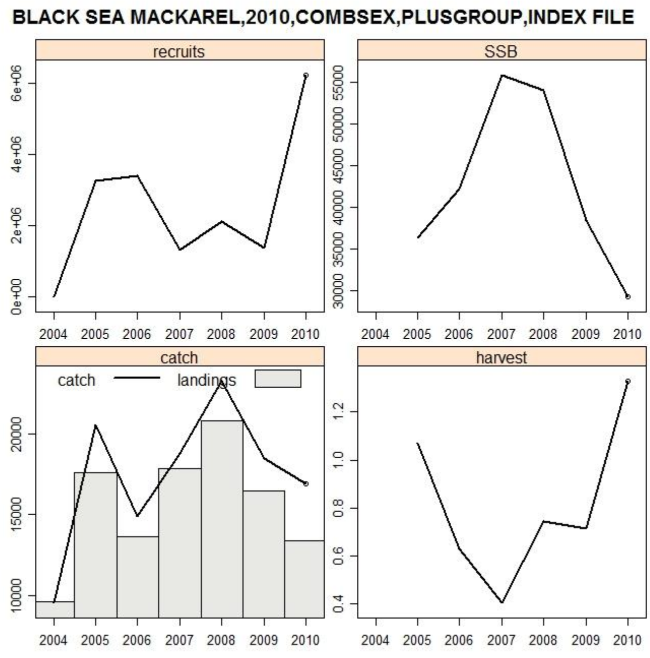


Figure 6.6: Time-series of horse mackerel population estimates of total stock in the Black Sea (FLR for Quantitative Fisheries Stock Assessment Analysis with terminal F =0.8): A. recruitment (line) and stock spawning biomass (SSB); B. landings (grey) and catch (line) (after Daskalov et al., 2011).

The following results are derived from the separable VPA based on a terminal F=1.2.

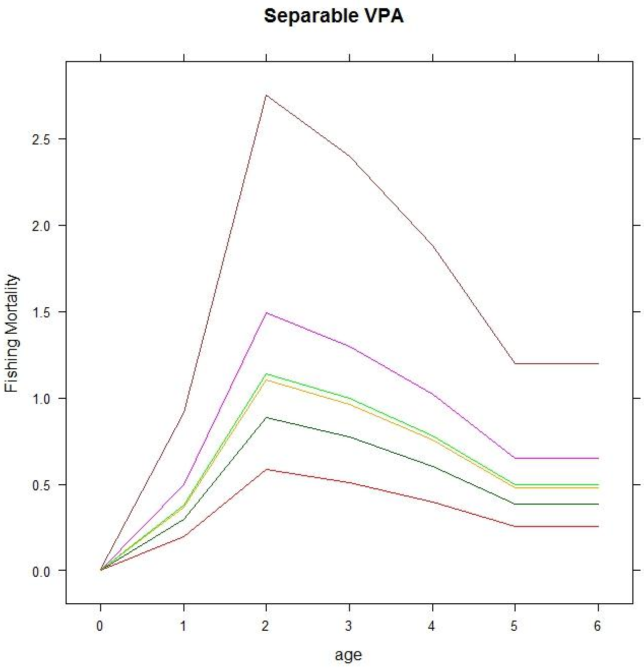


Figure 6.7: Selection patterns as derived from the separable VPA with F=1.2 as terminal F(after Daskalov et al., 2011).

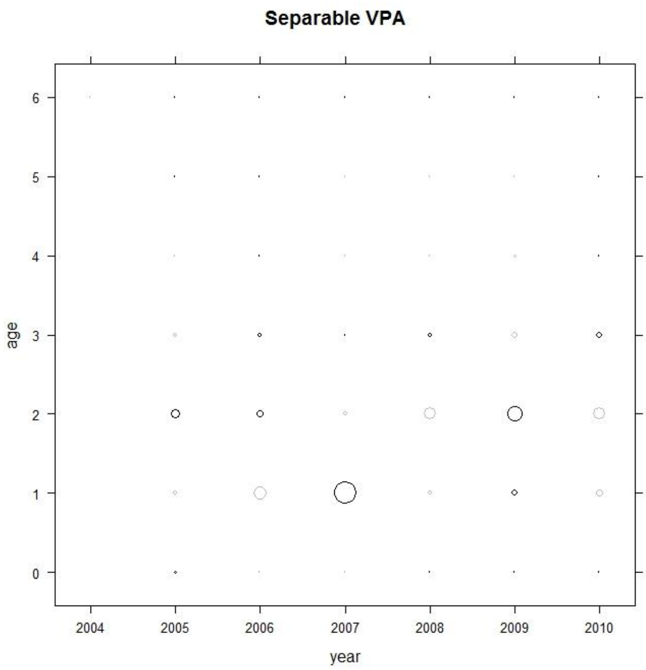


Figure 6.8: Residuals in estimated fishing mortalies(after Daskalov et al., 2011).

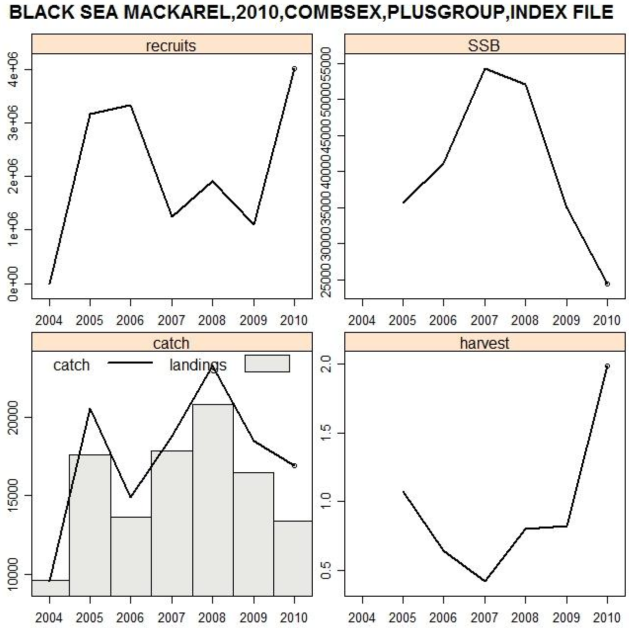


Figure 6.9: Time-series of horse mackerel population estimates of total stock in the Black Sea (FLR for Quantitative Fisheries Stock Assessment Analysis with terminal F =1.2): A. recruitment (line) and stock spawning biomass (SSB); B. landings (grey) and catch (line) (after Daskalov et al., 2011).

The following table summarizes all estimated trajectories of the stock parameters of all three scenarions considered of 3 separable VPA scenarios, (F=0.4, F=0.8 and F=1.2), SSB and landings in tons, recruitment R in thousands.

Table 6.1: Stock parameters of 3 separable VPA scenarios, (F=0.4, F=0.8 and F=1.2), SSB and landings in tons, recruitment R in thousands.

Year	SSB	R	F	Landings	
2004				9633.9	
2005	37754	3503593	1.04554	17602.4	**F=0.4**
2006	44866	3705772	0.59026	13625.33	
2007	60680	1500324	0.36512	17886.08	
2008	60606	2730272	0.61668	20842.85	
2009	49239	2194065	0.50969	16489.06	
2010	44361	13206063	0.67295	13405.5	
Year	**SSB**	**R**	**F**	**Landings**	
2004				9633.9	
2005	36378	3269500	1.07272	17602.4	**F=0.8**
2006	42208	3416658	0.62974	13625.33	
2007	55846	1307859	0.40783	17886.08	
2008	54009	2102241	0.74503	20842.85	
2009	38349	1369494	0.71608	16489.06	
2010	29302	6244820	1.32927	13405.5	
Year	**SSB**	**R**	**F**	**Landings**	
2004				9633.9	
2005	35723	3173891	1.07638	17602.4	**F=1.2**
2006	41197	3329170	0.6402	13625.33	
2007	54292	1252966	0.42204	17886.08	
2008	52047	1905232	0.79687	20842.85	
2009	35029	1093149	0.82309	16489.06	
2010	24508	4022171	1.98612	13405.5	

6.2 Robustness analysis

N/A

6.3 Assessment quality

N/A

7 Stock predictions

7.1 Short term predictions

The current state of the assessment does not allow any reliable formulation of a short term prediction of stock size and biomass under various management scenarios.

7.2 Medium term predictions

The current state of the assessment does not allow any reliable formulation of a medium term prediction of stock size and biomass under various management scenarios.

7.3 Long term predictions

The current state of the assessment does not allow any reliable formulation of a long term prediction of stock size and biomass to conclude on biological reference points consistent with high long term yields.

8 Draft scientific advice

The lack of a fishery independent scientific survey to monitor horse mackerel all over the Black Sea to indicate trends in total mortality and recruitment appears the major data deficiency in the assessment. EWG 11-16 recommends such survey to be established.

8.1 State of the spawning stock size

The assessment is considered only indicative of relative stock trends. All three assessment formulations indicate that the SSB in 2010 is reduced from a higher level. In the absence of total stock size estimates and biological reference points, EWG 11-16 is unable to fully evaluate the stock size with regard to the precautionary approach.

8.2 State of recruitment

Recruitment is indicated to have varied without a clear trend since 2004.

8.3 State of exploitation:

Given the current state of the assessment of horse mackerel in the Black Sea, it is unable to provide a biological reference point consistent with high long term yield nor to quantify the exploitation rate. Based on the assessment results the exploitation rate appears to have varied since 2004 without a clear trend. In the absence of a biological reference points, it is unable to fully evaluate the exploitation state with regard to the precautionary approach.

Medium term considerations

Given the current state of the assessment of horse mackerel in the Black Sea, it is unable to provide advice for the medium term future.

Table 8.1: Unidimensional stock status (choose one)

Unidimnsional	**Not known or uncertain.** Not much information is available to make a judgment; **Underexploited, undeveloped or new fishery.** Believed to have a significant potential for expansion in total production; **Moderately exploited**, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production; **Fully exploited.** The fishery is operating at or close to an optimal yield level, with no expected room for further expansion; **Overexploited.** The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse; **Depleted.** Catches are well below historical levels, irrespective of the amount of fishing effort exerted; **Recovering.** Catches are again increasing after having been depleted or a collapse from a previous; **None** of the above.

Table 8.2: Bidimensional stock status

	Exploitation rate	Stock Abundance
Bidimensional		

Please note the two new definitions provided by the SAC:

> ***Overfished (or overexploited)*** - *A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*
> ***Stock subjected to overfishing (or overexploitation)*** - *A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers)*